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WORK PLAN

REMEDIAL INVESTIGATION (RI)/FEASIBILITY STUDY (FS)

McINTOSH PLANT SITE
OLIN CORPORATION
McINTOSH, ALABAMA

for:

Olin Corporation
Charleston, Tennessee

May 1991

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Olin Chemicals McIntosh plant is located approximately one mile east-southeast of the town of McIntosh, in Washington County, Alabama. A site location map is presented in Figure 1.

Olin operated a mercury cell chlorine-caustic soda plant on a portion of the site from 1952 through December 1982. In 1954, Olin began construction of a pentachloronitrobenzene (PCNB) plant on an adjacent portion of the site. The plant was completed and PCNB production was started in 1956. The McIntosh plant was expanded in 1973 to produce trichloroacetonitrile (TCAN) and 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole (Terrazole). The PCNB, TCAN and Terrazole manufacturing areas were collectively referred to as the Crop Protection Chemicals (CPC) plant. In 1978, Olin constructed a diaphragm cell caustic soda/chlorine plant which is still in operation. The CPC plant and mercury cell plant were shut down in late 1982. The McIntosh plant continues to operate and produce chlorine, caustic soda, sodium hypochlorite, sodium chloride and blends hydrazine.

The Olin McIntosh plant currently monitors and reports on numerous facilities permitted through the U.S Environmental Protection Agency (EPA) and the Alabama Department of Environmental Management (ADEM). These include water and air permits as well as a Resource Conservation and Recovery Act (RCRA) post-closure permit (including a groundwater corrective action pumping/treatment program), Solid Waste Management Unit (SWMU) closures, three injection wells for mining salt and a neutralization/percolation field.

In September 1984, Olin's McIntosh plant site was placed on the National Priority List of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or "Superfund". Groundwater contamination at the site has been established based on the results of various investigations. Mercury and chloroform are the principal contaminants identified at the site. Mercury contamination was evidently caused by the operation of the mercury cell chlor-alkali plant during the period 1952 to 1982. The chloroform contamination is probably a degradation product from the operation of the CPC plant from 1954 to 1982.

Investigations have also indicated contamination in a 65-acre natural lake, herein referred to as the "basin," located on the Olin property east of the active plant facilities. This basin received plant wastewater discharge from 1952 to 1974.

In November 1989, Olin submitted a Remedial Investigation/Risk Assessment (RI/RA) report to EPA for the McIntosh facility (ERM, 1989). This report was prepared to present all relevant data, interpretations, findings and conclusions arising from previous groundwater and soils investigations, the ongoing RCRA groundwater corrective action program, and other environmental investigations that have been conducted by Olin at the McIntosh facility.

On December 5, 1989, representatives of the EPA met with Olin representatives to discuss the McIntosh site, including the adequacy of Olin's previously submitted RI/RA report (ERM, 1989) and an Administrative Order by Consent for Olin to conduct further work. The EPA indicated it would determine the adequacy based on: (1) a review of the data to ascertain completeness and (2) a determination as to whether the appropriate Quality Assurance/Quality Control (QA/QC) protocols were met during the collection and analysis of the data presented in the RI/RA report.

On January 15, 1990, Olin received a special notice letter from the EPA announcing EPA's intent to conduct an RI/FS beginning in June 1990. Olin was invited to respond to EPA with a Remedial Investigation and Feasibility Studies (RI/FS) Scope of Work to provide a basis for further negotiations. Olin submitted a draft Scope of Work to EPA on March 15, 1990. On April 9 and April 10, 1990, Olin and its consultants met with EPA Region IV representatives in Atlanta and discussed this draft. In response to comments by EPA, Olin revised the Scope of Work and submitted the final draft to the EPA on April 25, 1990.

On May 2, 1990, Olin signed the Administrative Order by Consent (Consent Order) issued by EPA for the preparation, performance and oversight costs for the RI/FS at the McIntosh plant site. The final Scope of Work was attached to the Consent Order, which became effective May 9, 1990. This RI/FS Work Plan has been developed as partial fulfillment of the scoping document requirements of the Consent Order. Preparation of the Sampling and Analysis Plan (SAP) and Health and Safety Plan (HSP) constitute the other parts of the scoping document requirements.

Two operable units have been designated for the facility. Operable Unit 1 (OU-1) is the RCRA plant area (all of the Olin property except the area defined as OU-2). Operable Unit 2 (OU-2) is the basin, including the wetlands within the Olin property line and the wastewater ditch leading to the basin. Figure 2 is a facility layout map delineating the boundaries of the two operable units.

1.2 OBJECTIVE AND SCOPE OF WORK

The following are the objectives of the RI/FS at Olin's McIntosh plant site developed from the RI/FS Scope of Work:

1. To investigate the nature and lateral and vertical extent of contamination at the site (waste types, concentrations and distributions) for all potentially affected media (e.g., air, groundwater, soil, surface water and sediment), including confirmation of the results of previous investigations. The investigation of the lateral and vertical extent of contamination will include an evaluation of the potential for migration beyond the boundaries of the two operable units.

2. To refine and expand the results of the previously submitted Baseline Risk Assessment to assess the current and potential risk to public health, welfare, and the environment.

3. To develop and evaluate alternatives for an appropriate remedial action to prevent or mitigate the migration, release or threatened release of contaminants from the site.

The objective of the work plan is to provide the methodology and approach for performing the RI/FS tasks. This work plan has been developed in accordance with Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01, "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final," (OSWER, October 1988) and the above-referenced Consent Order.

The work plan includes an initial evaluation of remedial response alternatives to assist in the development of the work plan rationale and further develop the scope of the RI tasks. Additionally, the activities associated with each phase of work are identified and the methodologies are defined for each activity. This work plan is to be implemented in conjunction with the Sampling and Analysis Plan (SAP) and Health and Safety Plan (HSP) as required by the Consent Order.

The RI/FS work for both operable units (OU-1 and OU-2) will be conducted concurrently to meet RI/FS requirements and objectives.

1.3 SUMMARY OF PREVIOUS INVESTIGATIONS

Extensive investigations and other data collection activities have been conducted at the Olin McIntosh facility, primarily through the RCRA programs and other voluntary activities conducted by Olin. These data have been submitted in their entirety to EPA previously in the following documents:

- The seven volume 1989 RI/RA report.
- The closure reports for the various closed and clean closed SWMUs.
- The semiannual groundwater monitoring reports.

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Figure 3 shows the locations of all monitor, corrective action and process water production wells that have been installed at the facility.

This section summarizes the previous investigations that appear to be most relevant to the RI/FS. The investigations are discussed chronologically.

There have been several soil investigations conducted at the Olin facility for plant construction projects. In 1975 Dixie Laboratories completed 40 soil borings at the facility to a depth of 30 feet (Dixie, 1975). The investigation included general geotechnical soil testing (e.g., specific gravity, moisture content, Atterberg limits, unconfined compression strength and permeability). The soils were also tested for pH. Law Engineering Testing Company (1976) also conducted a geotechnical investigation. Thirty borings were completed to a maximum depth of 50 feet. Soil samples were tested for geotechnical properties and soil pH. The Dixie and Law investigations provide extensive data on the near-surface stratigraphy and physical properties of the near-surface soils.

In 1976, an extensive Environmental Impact Study (EIS) was conducted by J. B. Converse, Inc. and Betz Environmental Engineers under a third-party agreement between Olin, EPA Region IV and the contractors (Betz and Converse, 1977). The purpose of this EIS was to evaluate the impact of the construction of a chlor-alkali diaphragm cell process at the McIntosh plant site. With minimum environmental impact indicated, chlorine and caustic capacity was increased in 1977. The EIS provides extensive information on air quality, topography, geology, soils, climate, terrestrial ecology, surface water, aquatic ecology, groundwater and socioeconomics for the McIntosh area.

In 1980, Olin Corporation initiated an internal program to determine whether any groundwater contamination existed onsite. The program included the installation of 43 monitoring wells, 12 of which were for compliance with RCRA regulations for detection monitoring of hazardous constituent releases from Solid Waste Management Units (SWMUs). The result of Olin's study revealed contamination of the groundwater by chlorinated organic compounds and mercury.

In March 1982, Soil and Materials Engineers, Inc. (S&ME) was retained by Olin to perform a hydrogeological investigation of the McIntosh site to assess the migration and extent of organic contaminants in the groundwater (S&ME, 1982). The investigation included the installation of 32 additional monitoring wells and groundwater sampling of both new and existing wells. The field investigation was completed in August 1982, with the final report submitted to ADEM and EPA in November 1982. The report established the direction of groundwater flow and defined the hydrogeological parameters of the area. The study also identified two plumes of chlorinated organic contaminants (predominantly, chloroform, benzene, chlorobenzene and dichlorobenzene) in the Alluvial Aquifer. The hydrogeological data indicated this aquifer is separated from the deeper Miocene Aquifer by a low-permeability clay aquitard. The report further indicated that this aquitard inhibits downward migration of the contaminant plumes.

To further define the migration of the plumes identified by S&ME, Olin Corporation installed 14 additional monitoring wells between February and March of 1983.

During the period from 1982 to 1986, Olin closed the RCRA regulated units at the McIntosh plant. The sampling programs associated with these closures provide data regarding the potential mobility of constituents as indicated by the RCRA Extraction Procedure results. Soil sampling that was conducted to fulfill the clean closure requirements for the RCRA surface impoundments are discussed in more detail in Section 3.1.1.

Since 1984, Olin has continued its RCRA groundwater detection monitoring program. Ten additional monitoring wells have been installed on the eastern perimeter of the plant to further define the migration of contaminants to the east/southeast. In July 1987, construction was completed on the groundwater Corrective Action Program (CAP). The five-well system became operational in August 1987.

In 1986, Olin conducted limited fish sampling in the basin. Eight species of fish were collected and the samples analyzed for total mercury and chlorinated benzenes (dichlorobenzene, trichlorobenzene, tetrachlorobenzene, pentachlorobenzene, hexachlorobenzene and pentachloronitrobenzene). Table 1 summarizes the results of the fish sampling. The detected mercury concentrations ranged from 0.12 mg/kg to 1.89 mg/kg. The total chlorinated benzene concentrations ranged from 0.03 mg/kg to 4.19 mg/kg. Due to the limited sampling and the informal protocols no definitive conclusions were made from the fish analyses data.

In October 1987, Olin conducted a study of the basin area according to a study plan reviewed and approved by EPA (Olin, 1988). The basin area study was designed to address data deficiencies identified by EPA's subcontractor in a 1985 Forward Planning Study by assessing potential releases of hazardous constituents to the basin area. The study included collection and analyses of eight surface water samples and ten sediment samples. Mercury was detected in the surface water at a maximum concentration of 2.0 μg/l. Mercury concentrations detected in the ten sediment samples ranged from 0.4 mg/kg to 60.5 mg/kg. Replicate sample concentrations ranged from <0.3 mg/kg to 9.5 mg/kg. Organics were detected in five of the ten samples. The most common organic constituent detected was hexachlorobenzene. The 1987 basin investigation is discussed in more detail in Section 3.1.2.

In 1989 an RI/RA report was prepared for Olin by ERM (ERM, 1989). The purpose of the RI/RA report was to present all relevant data, interpretations, findings and conclusions arising from the groundwater investigations, the ongoing RCRA detection program, RCRA SWMU closures, the ongoing RCRA Corrective Action Program, and other studies conducted by Olin at the McIntosh facility from 1980 through 1989. These various sources of data provided the background for evaluation of current site conditions with regard to groundwater flow migration pathways, the extent of aqueous contamination within the groundwater system, and the impact of the site on sediments and surface water of the basin area. The evaluation of the current site conditions was also utilized for an assessment of the potential risk to the public from site contaminants.

EPA has reviewed the 1989 RI/RA and provided comments on it, pointing out some factual inaccuracies and suggesting data presentation alternatives. This Work Plan has been prepared to be sensitive to EPA's comments (a more detailed response to the comments was submitted separately).

2.0
SITE BACKGROUND AND SETTING

The information on the site background and setting presented in this section has been obtained from the 1989 RI/RA Report (ERM, 1989).

The Olin plant is located approximately one mile east-southeast of the town of McIntosh, in Washington County, Alabama (Figure 1). The property is bounded on the east by the Tombigbee River, on the west by land west of U. S. Highway 43, on the north by the Ciba-Geigy Corporation plant site and on the south by River Road.

The regional setting for the site is the East Gulf Coastal Plain Physiographic Province. Specifically, the 1500 acres that comprise the Olin property is within the Southern Pine Hills District.

2.1 SITE DESCRIPTION

The Olin McIntosh plant is an active chemical production facility. The main plant and associated Olin properties cover approximately 1,500 acres, with active plant production areas occupying approximately 60 acres. Current active facilities at the plant include: a diaphragm cell chlorine and caustic production process area; a caustic concentration process area; a caustic plant salt process area; a hydrazine blending process area, shipping and transport facilities; process water storage, transport and treatment facilities; and support and office areas. Beyond the active production facilities, the Olin property is heavily forested. The basin area is located on the Olin property, adjacent to the Tombigbee River and east of the active plant facilities.

As discussed in Section 1.0, two operable units (OU-1 and OU-2) have been designated for the facility. Figure 2 is a facility layout map of the Olin McIntosh plant, which shows the boundaries of the two operable units.

2.1.1 Operable Unit 1

Operable Unit 1 is all Olin property excluding the area designated as Operable Unit 2. Within OU-1 are the following closed, inactive and active Solid Waste Management Units (SWMUs):

1. Stormwater pond
2. Brine filter backwash pond
3. Pollution abatement (pH) pond
4. Weak brine pond
5. Mercury waste pile storage pad
6. TCAN hydrolyzer
7. Mercury drum storage pad
8. Chromium drum storage pad
9. PCB/Hexachlorobenzene storage building
10. Hazardous waste drum (flammable storage pad)
11. Sanitary landfills (2)
12. Old plant (CPC) landfill
13. Inactive ash ponds (2)
14. Active ash pond
15. Lime ponds (2)
16. Diaphragm cell brine pond and overflow basin
17. Hexachlorobenzene spoil area (removed)

2.1.2 Operable Unit 2

Operable Unit 2 consists of the basin (65-acre lake), the wetlands within the Olin property line, and the wastewater ditch leading to the basin. The basin received wastewater from the Olin facility from 1952 to 1974. During the seasonal high water levels (approximately 4 to 6 months per year), the basin is inundated by, and thus becomes contiguous with the adjacent Tombigbee River.

2.2 SITE CONDITIONS

Most of the information provided here on the general site conditions of the McIntosh plant is extracted from ERM (1989).

2.2.1 Climatological Information

The following information is based on data from the climatological station in Mobile (approximately 50 miles south of McIntosh).

The McIntosh plant site is typically humid year-round with a subtropical climate. The average annual temperature is about 68°F, with July having the highest average temperature of 82°F and January having the lowest average temperature of 50°F.

South Alabama's annual rainfall is among the highest in the United States, averaging about 64 inches. The precipitation is relatively evenly distributed over the year, although there is a small peak in July during the thunderstorm season, when monthly rainfall averages 7.6 inches. The driest season runs from October through November, when the monthly average is 3.5 inches. Thunderstorms, the predominant mode of precipitation, occur on an average of 80 days a year, more frequently in summer than other seasons.

Wind flow patterns are variable throughout the year, but there are some broad seasonal patterns. From September through February, winds are dominantly in a northerly direction, with dominant southerly and southeasterly winds the remainder of the year.

2.2.2 Topography

The active production areas of the plant are relatively flat with little topographic variation (Figure 1). The elevation varies from about 40 feet (MSL) to less than 20 feet (MSL) in a drainage ditch on the east side of the plant. Elevations elsewhere on the property (outside of the main plant area) range from approximately sea level in the basin to greater than 40 feet (MSL) in the northwest corner of the property. The most distinctive topographic feature is the steep bluff located approximately 4,000 feet east of the main plant area. This bluff defines the edge of the low-lying basin area, which is about 20 feet lower in elevation than the property to the west.

Surface drainage from the main plant production areas is directed through a series of concrete-lined channels to an NPDES-permitted discharge. Beyond the main plant area, natural drainage flows westward to Bilbo Creek and eastward to the Tombigbee River, the primary surface water body near the site. The basin itself drains to the Tombigbee River. Regional drainage patterns will be investigated and additional, site-specific topographic information will be obtained during the RI/FS.

2.2.3 Vegetation

Investigations have been conducted to characterize the vegetation at the Olin site. The following paragraphs, extracted from ERM (1989), summarize the work done in this regard.

The past studies of this terrestrial vegetation within a five-mile radius of the Olin site indicated about half of the region's vegetation is bottom-land forest. Mixed hardwood-pine forest accounts for about 30 percent of the area. Wetlands and potential wetlands (bottom-land hardwood) represent 5 to 17 percent of the total area. Unique flora and vegetation types include two exceptionally large trees located in a swamp bordering Lewis Creek. These are a bald cypress and a tupelo, each about 90 feet tall. Areas around the Olin basin are populated by cattail marsh and swamp forest.

Wetlands and water-land interfaces at the site include stream banks, lake shores, marshes, swamps, and bogs, the latter of which are covered during part of the year by natural, non-flood waters. The majority of the wetlands identified on and in the vicinity of the site during 1976 were associated with the flood plains of the Tombigbee River and its tributaries. These systems include palustrine-forested wetlands and palustrine-emergent wetlands. The neighboring upland areas identified in the study are hardwood and pine forests.

2.2.4 Regional Geology

Washington County is located in the Southern Pine Hills District of the East Gulf Coastal Plain Province. The McIntosh area is underlain by alternating beds of unconsolidated-to-consolidated sedimentary rocks that are collectively hundreds of feet thick (Moore, 1971). These rocks dip southwesterly at 30 to 50 feet per mile. The general dip of these rocks is locally interrupted by folds, faults and salt domes. The McIntosh salt dome is the most distinctive structural feature of the area.

Near-surface strata consist of Quaternary alluvial terrace and flood plain sediments deposited by the Tombigbee River. The Quaternary sediments range in thickness from 80 to 100 feet and consist of beds of sand, gravel, silt and clay, which form the Alluvial Aquifer system.

The Alluvial Aquifer is underlain by Miocene sediments. The Miocene Series is composed of alluvial deposits of fine-to-coarse-grained gravel, sand, sandstone and beds of gray to varicolored clay. The Miocene Series varies in thickness from less than 275 feet above the McIntosh dome to as much as 600 feet away from the dome.

The sands and gravels of the Miocene Series are aquifers, which constitute the most important source of groundwater in the McIntosh area. A Miocene clay strata, which varies in thickness from 80 to 100 feet, lies between the Alluvial Aquifer and the Miocene Aquifer.

2.2.5 Drainage

The majority of surface runoff from the site flows east and southeast to an unnamed tributary, which discharges into the Tombigbee River farther to the southeast. The surface runoff of the western-most portion of the site flows west to Bilbo Creek and ultimately into the Tombigbee River. Drainage from the main plant area is through a system of manmade culverts and ditches, which direct the runoff east and southeast toward the Tombigbee River.

2.2.6 Subsurface Stratigraphy

The near-surface stratigraphy has been defined from soil borings for numerous geotechnical and environmental investigations. Based on descriptions from Soils and Materials Engineers (S&ME 1982) and ERM (1989), the general stratigraphy is as follows:

Unit	Description
Q_1 (Upper Clay Unit)	Red-brown to yellow-brown and gray silty, sandy, plastic clay with discontinuous sand and silt lenses. (Q_1 Unit is reportedly 1 to 15 feet thick.)
Q_2 (Alluvial Aquifer)	Very fine to fine-grained silty sand in the upper part and fine to coarse-grained sand with varying amounts of gravel in the lower part. Contains thin beds of clay or silty, gravelly clay (Q_2 unit is reportedly 80 to 100 feet thick.)
Tm_1 (Upper Miocene Confining Unit)	Interpreted to be continuous across the site, consisting predominantly of clay with laterally discontinuous sands and silts. (Tm_1 unit is reportedly 80 to 100 feet thick.)
Tm_2 (Upper Miocene Aquifer)	Primarily thick-bedded, coarse sand and gravel. A clayey unit 10 feet to 30 feet thick occurs within this unit. (Thickness of Tm_2 unit is not well defined and varies with influence of the McIntosh salt dome.)

2.2.7 Hydrogeology

Two aquifers are of concern at the site, the Alluvial Aquifer and the Miocene Aquifer. The Miocene Aquifer is the major groundwater source in the area.

The Alluvial Aquifer is semi-confined and contains discontinuous zones of fine sand, clay and silt; however, these zones do not form a hydrologic boundary. Recharge to the Alluvial Aquifer is from surface infiltration. The aquifer has been contaminated by site constituents and a corrective action program was implemented to remediate this contamination.

The Miocene Aquifer is a confined artesian aquifer, which is not subject to significant leakage from the overlying Alluvial Aquifer. Recharge to the Miocene is by direct infiltration through surficial deposits updip of the facility where the Miocene Aquifer outcrops, to the northwest of the town of McIntosh (S&ME, 1982). The onsite stratigraphic data indicates that in the Olin plant area the aquitard between the Alluvial and Miocene Aquifers is the upper Miocene Confining Unit described above (80 to 100 feet thick). Groundwater contamination has been reported in the Miocene Aquifer at low concentrations during sampling events that were conducted six to nine years ago. Table 2 summarizes the sample analyses from the Miocene Aquifer. The validity of these old data is questionable. Additional sampling is planned during the RI/FS to confirm whether contamination does exist in the Miocene Aquifer.

Appendix A includes a map of the pre-corrective action potentiometric surface of the Alluvial Aquifer (October 1987) and a map of the February 1989 potentiometric surface after the corrective action was implemented. These potentiometric maps were obtained directly from the 1989 RI/RA (ERM, 1989). The natural (pre-corrective action) groundwater flow in the Alluvial Aquifer was generally southward from the north property boundary. Due to the topography of the underlying Miocene confining layer and local site recharge areas, the flow divides into western and eastern components. The eastward component discharges to the Tombigbee River. The westward component is influenced by a linear depression in the upper Miocene confining unit. The westward flow is further complicated by a hydraulic mound near the western property boundary, which diverts flow southwardly again. Olin has postulated that this mound is due to the presence of the salt dome. The Alluvial Aquifer ranges in thickness from 80 to 100 feet, with a saturated thickness ranging from 45 to 70 feet. In the vicinity of the site, the average transmissivity is estimated to be 8,500 ft^2/day, and the specific yield is estimated to be 0.20 (S&ME 1982).

The regional groundwater flow direction in the Miocene Aquifer is generally to the southwest. However, Olin has six active process water wells screened in the Miocene, with a minimum of any two pumping at all times (at approximately 1,000 gpm each). Therefore, flow is interpreted to be radially toward these pumping wells based on the preliminary calculations of the drawdown produced by pumping that were included in Olin's April 25, 1991 responses to EPA comments on the Work Plan. A more thorough evaluation of groundwater flow and drawdown in the Miocene will be conducted during the RI/FS. The average transmissivity of the Miocene Aquifer north of the Olin facility is estimated to be 6,950 ft^2/day (P. E. LaMoreaux, 1984).

2.3 REGULATORY BACKGROUND

Olin Chemical currently operates a diaphragm cell chlor-alkali facility at its plant in McIntosh, Alabama for production of chlorine, caustic, sodium hypochlorite and caustic plant (CP) salt. In addition, rocket fuel components are formulated in an onsite blending facility.

The Olin McIntosh plant currently monitors and reports on several facilities permitted by the EPA and the Alabama Department of Environmental Management (ADEM). These permits include 17 air permits, one NPDES with 5 outfalls, one RCRA post-closure permit (including several SWMUs and a groundwater corrective action program), one Class III injection well and one Class V Underground Injection Control (UIC) well.

2.3.1 State and Federal Activities

EPA became involved with the facility in 1976 with the Betz and Converse Environmental Impact study conducted prior to the construction of the chlor-alkali plant. This study was jointly implemented under a third-party agreement among Olin, EPA and the contractors.

The facility came under RCRA in 1980 and Olin implemented a RCRA groundwater monitoring program. Chlorinated organic compounds (including chloroform) and mercury were detected in the Alluvial Aquifer in 1981. Olin conducted a series of groundwater assessment investigations to determine the nature and extent of contamination.

During 1982, Olin shut down the CPC and mercury-cell chlorine plants. The CPC plant was dismantled and decommissioned and the site was caped under a plan submitted to and approved by ADEM. The chlorine plant was dismantled and decommissioned between 1982 and 1989.

The Olin McIntosh plant was inspected by an EPA contractor in 1982 and 1983 to calculate a Hazardous Ranking Score (HRS). Despite the strong objections of both Olin and ADEM, the McIntosh plant was placed at position 320 on the National Priority List (NPL). EPA found the following hazardous substances associated with the site:

- Mercury
- Gama-hexachlorocyclohexane
- Hexachlorobenzene
- 1,2,4-trichlorobenzene
- 1,4-dichlorobenzene

From 1984 through 1985, Olin closed or clean-closed ten designated SWMUs. Each closure plan was reviewed and approved by EPA and/or ADEM. Closures were certified at completion and releases from financial responsibility were obtained. These closures are described in more detail in Section 3.0. In 1987, with EPA/ADEM approval, Olin initiated a RCRA Corrective Action Program (CAP), consisting of five groundwater pumping wells in the Alluvial Aquifer with individual treatment systems at each well. Since implementation of the CAP, groundwater contamination has been observed to decrease at the RCRA compliance boundaries.

In 1986, Camp, Dresser and McKee, Inc. (CDM) conducted a Forward Planning Study and reported that Olin does not comply with the CERCLA policy requirements regarding the protection of wetlands and 40 CFR Part 6 (CDM, 1986). The basin area study (Olin, 1988) was implemented in response to the CDM study.

During 1988 Olin closed four of six former mercury cell brine wells under Olin's Underground Injection Control (UIC) permit. The only other two mercury cell brine wells (Brine Well No. 1 and Brine Well No. 2 had been previously plugged in 1972 in 1985, respectively. These pluggages were also approved under the UIC permit. These wells were all associated with the mercury-cell chlorine plant closed in 1982 and the cavities contain brine with a low concentration of mercury.

In June 1989, EPA and Olin agreed that all data and information developed in the course of Olin's extensive RCRA compliance activities would be collated into a Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Remedial Investigation (RI) formal report consistent with the October 1988 U.S. EPA guidelines.

In November 1989, Olin submitted to EPA an RI/RA report for the site (ERM, 1989). On January 15, 1990, Olin received a Special Notice letter from EPA requiring the development of the Scope of Work for the RI/FS. In response to the Special Notice letter, the Scope of Work for the RI/FS was developed and submitted to EPA in April 1990. On May 9, 1990, an Administrative Order of Consent (Consent Order) became effective for the performance of the RI/FS at the Olin Chemicals/McIntosh Site in McIntosh, Alabama. The Scope of Work was attached to the Consent Order.

An initial evaluation of OU-1 and OU-2 was performed to determine the types and volumes of waste present at the site and their potential pathways and impact. The evaluation was based on existing data from the ERM Report (ERM, 1989) and previous investigations. This evaluation provides the basis for the Work Plan Rationale (Section 4.0) and the subsequent RI/FS Tasks and Subtasks (Section 5.0). The results of the initial evaluation are presented in the following sections.

3.1 TYPES AND VOLUMES OF WASTE PRESENT

Since 1980, when Olin implemented RCRA compliance activities for the plant site, a number of facilities have been identified as likely or potential contamination source areas. In the past ten years, Olin has completed several activities in terms of source control, identification of SWMUs, closure and post-closure of SWMUs, monitoring of RCRA and NPDES permits and a corrective action program as described in Section 2.0. This section discusses the significance of the likely or potential contaminant sources and the extent of contamination.

3.1.1 Operable Unit 1

The potential contaminant sources identified in OU-1 include the following:

- Closed SWMUs regulated under 40 CFR 265
- Closed SWMUs not regulated under 40 CFR 265
- Active non-hazardous surface impoundments
- Inactive non-hazardous surface impoundments
- Additional potential source areas

The SWMUs and their regulatory status are summarized below:

SWMUs CLOSED OR CLEAN-CLOSED UNDER 40 CFR 265

Name	Approval ADEM	Approval U.S. EPA
1. Stormwater pond (clean closed)	May 1, 1986	April 28, 1986
2. Brine filter backwash pond (clean closed)	May 1, 1986	April 28, 1986
3. Pollution abatement (pH) pond (clean closed)	August 14, 1985	August 13, 1985
4. Weak brine pond (closed)	August 9, 1987	June 24, 1987
5. Mercury waste pile storage pad (clean closed)	March 12, 1985	(ADEM had Interim Status Authority)
6. TCAN hydrolyzer (clean closed)	March 21, 1984	(ADEM had Interim Status Authority)
7. Mercury drum storage pad (clean closed)	March 12, 1985	(ADEM had Interim Status Authority)
8. Chromium drum storage pad (clean closed)	February 25, 1986	March 31, 1986
9. PCB/Hexachloro-benzene storage building (clean closed)	February 25, 1986	March 31, 1986
10. Hazardous waste drum (flammable) storage pad (clean closed)	February 25, 1986	March 31, 1986

SWMUs NOT REGULATED UNDER 40 CFR 265

An additional 10 SWMUs not regulated under 40 CFR 265 have been identified within OU-1. These include the following:

Name	Status
Sanitary Landfills (2)	Closed, 1978 and 1984
Old Plant (Crop Protection Chemicals) Landfill	Closed 1984
Diaphragm Cell Brine Pond and Overflow Basin.	Active
Ash Ponds (3)	1 Active and 2 Inactive
Lime Ponds (2)	Inactive (Closed in 1978 prior to RCRA)
Hexachlorobenzene Spoil Area	Removed Under CERCLA Emergency Removal Action, 1990

3.1.1.1 SWMUs Closed Under 40 CFR 265

As outlined above, Olin has either closed or clean-closed ten SWMUs under 40 CFR 265 since 1984. These closures are described below:

- Stormwater Pond. The stormwater pond is a clay-lined earthen structure approximately 100 feet by 365 feet, with a maximum volume of 500 cubic yards of settled solids. The stormwater retention pond received stormwater runoff from the mercury cell chlor-alkali processing area perimeter. Since stormwater pond solids were contaminated with mercury, the pond was designated as a hazardous waste unit. The pond was originally constructed with natural clay of low permeability as a liner. The clay liner was compacted to 95 percent of the proctor density.

Closure of this unit consisted of liquid removal, onsite treatment and discharge through Outfall 001 in accordance with the NPDES permit requirements. Accumulated solids and portions of the clay liner material were removed to a depth of approximately one foot and placed in the weak brine pond. After excavation and transfer of the solids and liner material, the bottom and sides of the pond were tested for mercury by means of the EP Toxicity test procedure. The clean closure criterion was the EP Toxicity regulatory limit for mercury of 200 $\mu g/l$. A total of ten samples were collected and analyzed. The sample locations and results are shown in Figure 4. All samples tested below 2.0 $\mu g/l$ using the EP Toxicity leachate procedure, one-hundred times less than the regulatory limit.

The stormwater retention pond is presently lined with a clay liner and is not being used at this time. On the basis of the ADEM and EPA closure approvals, the stormwater retention pond is no longer subject to RCRA 40 CFR 265 requirements.

- Brine Filter Backwash Pond. The brine filter backwash pond was an earthen structure approximately 200 feet by 250 feet. It was lined with a geosynthetic membrane. The pond was designed to function as a holding pond for brine filter backwash water. The pond received wastewaters that included washdown, filter backwash and process water. The maximum inventory of settled solids was estimated to be approximately 600 cubic yards.

  Closure of this unit consisted of liquids removal, onsite treatment and discharge through Outfall 001 in accordance with the NPDES permit requirements. Accumulated settled solids overlying the synthetic liner were slurried and pumped to the weak brine pond. Four samples of the material underneath the liner were collected and analyzed for mercury using the EP Toxicity leachate procedure. The analyses showed mercury levels that ranged from <0.1 $\mu g/l$ to 0.9 $\mu g/l$ (ERM, 1989). The brine filter backwash pond is now closed as an active hazardous waste unit and is used as needed as an accessory process pond.

- Pollution Abatement (pH) Pond. The pH pond was a wastewater impoundment approximately 150 feet by 300 feet with a capacity of about 11,000 cubic yards. The bottom of the pond was constructed of a backfilled low-permeability clay approximately 2.0 feet thick. Existing information does not indicate whether the clay was compacted, although compaction to 95 percent of the Proctor density was the general plant construction standards. This pond was designed and constructed to handle corrosive wastewaters having a pH less than 2.0 or greater than 12.5. Wastewaters received for treatment included washdown from process areas, cooling tower blowdown, various process streams and contaminated stormwater runoff.

  The pollution abatement (pH) pond was used in the treatment of the process wastewater stream. Process wastewater was discharged into the pond for neutralization of high-and low-pH waters prior to polishing treatment in a three-stage neutralization tank system. The material discharged into the pond also contained mercury compounds. The estimated maximum inventory of settled solids was approximately 1600 cubic yards. As a result of the CPC plant shutdown in 1982 and other operational changes, the pH pond was no longer required to handle strongly acidic waste streams.

  Closure of this unit consisted of liquids removal, onsite treatment and discharge through Outfall 001 in accordance with the NPDES permit requirements. Accumulated solids and portions of the liner were removed to a depth of approximately two feet and placed in the weak brine pond. The depth of the solids is not known. After excavation and transfer of the solids and the liner, soil samples were collected from the pond bottom and analyzed for pH and mercury (by means of the EP Toxicity leachate procedure). The closure certifications indicate that mercury and pH levels in the pond bottom were within acceptable limits. The acceptable limits for pH were between 2.0 and 12.5 standard units. The acceptable limit for mercury was 200 $\mu g/l$, by the EP Toxicity procedure. The pH pond sample locations and results are shown in Figure 5. Six samples were analyzed for pH, with the resulting values between 11.4 and 11.5 standard units. The sample map showed eleven mercury sample locations; however, data are available from only eight of these locations. The reason for missing three sample results is unknown. These eight samples indicate EP Toxicity mercury values between 0.08 $\mu g/l$ and 4.1 $\mu g/l$. The unit was certified as clean-closed by ADEM and EPA. The unit is now lined with a synthetic membrane and is used as a non-hazardous wastewater holding pond.

- Weak Brine Pond. The weak brine pond was an earthen structure approximately 350 feet by 325 feet. Olin operated a mercury cell chlorine-caustic soda plant, of which the weak brine pond was an integral part. The weak post-process brine from the mercury cell units was discharged to the weak brine pond, where solids containing mercury were settled. Similarly, filter backwash and various other waste streams that contained mercury were discharged to weak brine pond. The strong brine pond was a process unit, not a waste facility, that was closed at the same time as the weak brine pond

The weak brine pond was also utilized during the closure of the three onsite surface impoundment units discussed above. The material removed from each of these impoundments was deposited in the weak brine pond and stabilized and solidified using cement dust. The total volume of consolidated waste in this unit is approximately 33,000 cubic yards.

Closure for this unit consisted of liquids removal, onsite treatment with an existing activated carbon system and discharge through Outfall 001 in accordance with the NPDES requirements.

After removal and treatment of the liquids, chemical stabilization/solidification materials and cement dust were added to the pond bottom sludges, along with dry soil pushed in from the dikes, to form a stable foundation for the final cover and cap material. Table 3 shows the results of a waste stabilization study that was conducted prior to closure (Olin, 1985). This table shows concentrations of constituents in the waste prior to solidification compared to the percent free liquids and metal concentrations from the EP Toxicity leachate procedures after solidification.

A composite support base of dike soil, native soil and clay was constructed using a 12-inch base of native soil and dike material followed by a six-inch cover of compacted clay material having a reported maximum permeability of 1×10^{-7} cm/sec. The clay was also compacted to a minimum 95 percent Proctor density, with the compaction and permeability being verified in the field by an independent soils testing laboratory. A 30-mil synthetic liner was then placed over the support base to provide an impervious membrane to the underlying material. A 12-inch sand drainage layer was placed over the synthetic liner to function as a drainage system to remove any water that resulted from rainfall and percolation through the overlying layers. The sand drainage layer was then covered with a geotextile fabric net and capped with a 6-inch layer of native compacted clay having a reported maximum permeability of 1×10^{-7} cm/sec, and a minimum compaction of 95 percent Proctor density. The clay liner was sloped at a minimum five percent grade and keyed into the natural clay material by a two-foot wide clay key that extends downward to the lowest elevation of the impoundment. A final cover of six inches of topsoil was installed, with seed (30 pounds/acre) and fertilizer being applied to establish rapid cover and prevent erosion of the cap system. The top cover was sloped at a five percent gradient. The entire cap was encircled by concrete-lined perimeter ditches sloped to drain into the plant drainage systems.

The weak brine pond cap was evaluated, as designed and constructed, using the Hydrologic Evaluation of Landfill Performance (HELP) computer model developed by the U. S. Army Corps of Engineers for the EPA. The HELP model demonstrated that the selected design would allow a maximum leakage of 0.0490 inches of liquid transmission per year due to percolation/infiltration and was the best alternative of the cap design variations that were considered.

The stability of the underlying consolidated base material was evaluated and found to be in the range of 3.5 tons/square foot, which is well above typical load-bearing capacities for reinforced concrete foundations. The potential for additional settlement is minimal, since the weak brine pond was in service for approximately 30 years and any consolidation of the underlying soils would probably have already occurred as a result of the weight of the liquids in the pond during its active life. Soil loss in the surface cover and cap will be minimized by the vegetation and periodic maintenance required by the RCRA post-closure permit.

- <u>Mercury Waste Pile Storage Pad.</u> The waste pile storage pad was used for storage of material contaminated during the mercury cell process operation (e.g., piping, etc.). In 1982, most of the contaminated materials were removed and shipped offsite for disposal. The unit was closed in 1985 by removing all the material and cleaning the concrete pad with sodium hypochlorite solution.

- <u>TCAN Hydrolyzer.</u> The TCAN (trichloroacetonitrile) hydrolyzer was a glass-lined agitation tank designed to hydrolyze the reactive residue from the TCAN distillation column. The residue was loaded in the hydrolyzer after being treated with a 20 percent sodium hydroxide solution for decomposition of the reactive component (TCAN). The non-reactive waste was then drained into 55-gallon drums for offsite disposal.

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All wastes were removed from the TCAN hydrolyzer tank in September 1981 and the unit was placed in standby status. The unit was then closed in 1984 by rinsing with a sodium hydroxide solution followed by a high-pressure, hot water rinse. All waste residues were collected and solidified for disposal in an offsite hazardous waste landfill. All liquids were collected and pumped through the facility's pH treatment system for neutralization and discharged through the NPDES-permitted outfall.

- Mercury Drum Storage Pad. The mercury drum storage pad was used to store drums that contained filters, sump sludges and other process waste containing mercury. This pad was located between mercury cell process buildings A and B. The unit consisted of a 40-foot-by-60-foot concrete storage pad used for drum storage of mercury-contaminated solids. The unit was closed by removing all the waste followed by decontamination of the area by sodium hypochlorite solution. All liquids were collected and discharged through the NPDES-permitted outfall.

- Chromium Drum Storage Pad. The chromium drum storage unit is a 30-foot-by-50-foot concrete pad that was used for storage of containerized chromium-contaminated solids and liquids. Maximum inventory of the unit reached approximately 6,600 gallons. Materials were removed and transported to an offsite hazardous waste treatment or disposal facility. The unit was washed with a sodium hypochlorite solution and flushed with clean water. All liquids were collected and discharged through the NPDES permitted outfall.

- PCB/Hexachlorobenzene Storage Building. The PCB/hexachlorobenzene building was a 60-foot by 120-foot steel frame building with ribbed siding. The building was used mainly for the storage of hexachlorobenzene, a waste material generated in the manufacture of PCNB. The building is currently equipped for storing Toxic Substance Control Act (TSCA)-regulated materials. The building is being used for general plant purposes and is not currently active as a storage facility. The unit was clean-closed for RCRA-regulated materials. Closure consisted of removal of materials and transportation to an off-site hazardous waste treatment/disposal facility. The unit was washed with a sodium hypochlorite solution and flushed with clean water. All liquids were collected and discharged through an NPDES-permitted outfall.

- Hazardous Waste Drum (Flammable) Storage Pad. The flammable waste drum storage facility is a 30-foot by 40-foot steel frame building with a concrete floor and partial siding. The building was used primarily for the storage of ignitable wastes. Currently the unit is used for storage of safety and emergency response equipment.

  This unit was clean-closed by removing all waste from the site and transporting it to an off-site hazardous waste treatment and disposal facility. The unit was washed with sodium hypochlorite solution and flushed with clean water. All liquids were collected and discharged through an NPDES-permitted outfall.

3.1.1.2 Closed SWMUs Not Regulated Under 40 CFR 265

In the past ten years, Olin has also closed three other areas located in OU-1 that were not regulated under 40 CFR 265. These are as follows:

- Sanitary Landfills

  Between 1976 and 1984, Olin operated two sanitary landfills, which received general, nonhazardous waste and plant refuse. The first unit was operated from 1976 to 1978. It was approximately 150 feet by 200 feet and contained about 4,000 cubic yards of material. The second unit was operated from 1978 to 1984. It was approximately 600 feet by 800 feet and contained about 18,000 cubic yards of material.

Both units were closed with a clay cap and vegetative cover under the existing solid waste management regulations established by the State of Alabama.

- Crop Protection Chemicals (CPC) Landfill

The site of the CPC landfill was utilized from 1952 to 1972 as an acid neutralization pond for the CPC plant. From 1972 to 1977, it was used as a disposal site for general plant debris. The site is approximately 300 feet by 400 feet and is estimated to have an 8,000-cubic-yard capacity. It was closed with a clay cap, topsoil and grass as approved by the Alabama Department of Environmental Management. The cap consists of a two-foot thick layer of compacted clay. A three-to six-inch layer of topsoil was placed over the clay cap to grow a grass cover. A three-foot-deep trench of recompacted clay was keyed into native clay around the entire perimeter of the landfill to limit leachate migration from the landfill.

- Hexachlorobenzene Spoil Area

The hexachlorobenzene spoil area site apparently was used in the past (date unknown) to dispose of soils from earth work in the former PCNB production facility. The area was discovered on October 11, 1990 while grading adjacent to the Temporary Ash Pond. On October 26, 1990, the EPA and Olin reached an agreement through an Administrative Order of Consent (AOC) for removal of the hexachlorobenzene-contaminated soil. The AOC required that any soils within the site that had hexachlorobenzene concentrations greater than 200 mg/kg be removed and transported offsite for disposal at an approved hazardous waste facility in compliance with EPA's off-site policy. A total of 11,407 tons of soil were excavated, transported and disposed of from October 27, 1990 to November 6, 1990. The excavated soil was sent to Chemical Waste Management's Carlyss, Louisiana, Landfill.

Confirmation soil samples were collected and analyzed for hexachlorobenzene to verify removal. The results of the confirmation samples are presented in Table 4. Figure 6 shows the confirmation soil sample locations.

3.1.1.3 Active Nonhazardous Surface Impoundments

- Diaphragm Cell Brine Pond and Overflow Basin

The diaphragm cell brine pond is approximately 300 feet by 360 feet with a 35,000-cubic-yard capacity. This pond is currently used as a settling basin for nonhazardous suspended solids from weak brine solutions prior to recycling the brine to brine wells. The brine cell pond and overflow basin were built in 1977. The overflow basin is smaller, approximately 150 feet by 360 feet, with a capacity of 26,000 cubic yards.

- Ash Pond

The active ash pond was built in 1981 and is currently used for nonhazardous boiler ash. It is approximately 480 feet by 870 feet with a 232,000-cubic-yard capacity.

3.1.1.4 Inactive Nonhazardous Units

- Ash Ponds

There are two inactive ash ponds located on the facility. The old ash pond was used as a settling pond for nonhazardous coal-fired boiler ash. It was built in 1976 and is approximately 200 feet by 300 feet with a 31,000-cubic-yard capacity. It is now used as a standby unit. The day ash pond was used for dewatering nonhazardous boiler ash. The pond is 300 feet in diameter with a 50,000-cubic-yard capacity. The day ash pond was also built in 1979.

Olin has indicated that chemical analyses of the ash have been conducted, and that the ash does not contain significant concentrations of hazardous constituents. Therefore these ponds are not considered sources.

- Lime Ponds

  There are two former lime ponds, the east and west ponds, which were not regulated under 40 CRF 265. The ponds were approximately the same size, but the west pond contained approximately 5,300 tons and the east pond approximately 4,200 tons. The ponds contain calcium chloride waste from the absorption and capture of residual chlorine gas, lime sludges and trace quantities of mercury. These two units operated from 1973 to 1976 and were closed in 1977-78 (prior to RCRA) with a clay cap, topsoil and grass.

3.1.1.5 Additional Potential Sources

The Crop Protection Chemical plant (CPC) was identified as a potential source during the S&ME investigation in 1982. The CPC plant was shut down in 1982. In 1984, the plant area was decommissioned, dismantled and covered with an approximate 2-foot recompacted clay cap, topsoil and vegetated. The plan for decommissioning and dismantling the CPC plant area was approved by ADEM in 1983 and the work was completed in accordance with that plan.

The 1989 ERM report discusses an "anomalous" source of unknown origin resulting in a localized area of organic contamination in groundwater about 2300 feet west of the CPC plant site. ERM based this conclusion on contours of groundwater concentrations. Olin believes this conclusion is incorrect. Olin has indicated that there was generally greater leakage of organics during the early years of CPC plant operations. These areas indicated by closed contours are believed to be due to a slug of contamination that has migrated from releases during these early years. Based on this interpretation, the groundwater contamination in this area came from the same source as contamination closer to the plant. Olin is committed to define the lateral extent of contamination in the Alluvial Aquifer during the RI/FS, which includes the slug of contamination near WP-6. The planned activities for groundwater characterization are presented in Section 5.3.2.3. These activities will adequately address the western plant groundwater. The RCRA Corrective Action wells CA-1 and CA-2 extract groundwater from this area. The baseline risk assessment under this work plan will address any risks to human health or the environment.

3.1.2 Operable Unit 2

As described in previous sections, Operable Unit 2 consists of the basin (a 65-acre lake), associated wetlands and the wastewater ditch leading to the basin. Figure 2 depicts the area included under Operable Unit 2.

From 1952 to 1974, plant wastewater discharge was routed through the basin and then to the Tombigbee River. In 1974, the discharge was rerouted directly to the discharge channel of the basin bypassing the basin itself. The discharge channel of the basin is approximately 800 feet long (during the non-flood season) and flows towards the Tombigbee River. The wastewater ditch currently carries the NPDES discharge toward the Tombigbee River and stormwater runoff from the east and southeast non-manufacturing property.

In 1988, Olin completed the Basin Study Report. The study was done to provide information for the remedial investigation in accordance with CERCLA and in response to the Forward Planning Study of 1986. Sampling of both sediment and water was conducted on December 8 and 9, 1987, under the observation of EPA Region IV officials. Sample locations for the sediment and surface water are presented in Figure 7. The results are summarized in Table 5. In addition to chemical analyses, temperature and pH profiles were obtained. The analytical parameters for the basin samples included:

Water	Sediment
Total mercury	Total mercury
1,2-dichlorobenzene	Soluble mercury
1,4-dichlorobenzene	1,2-dichlorobenzene
Hexachlorobenzene	1,4-dichlorobenzene
Pentachloronitrobenzene	Hexachlorobenzene
	Pentachloronitrobenzene

The mercury level detected in sediment ranged from <0.3 to 60.5 mg/kg across the basin. However, a duplicate sample analysis revealed a 9.0 mg/kg of mercury concentration corresponding to the 60.5 mg/kg value. Other sediment values ranged from 0.4 mg/kg to 25.5 mg/kg of mercury. Pentachloronitrobenzene (PCNB) was detected in three sediment samples, up to a maximum concentration of 14.5 ppm. Detection of PCNB was not confirmed in two of the three samples by replicate analysis. Hexachlorobenzene (HCB) was detected in five of the ten sediment samples. The detectable concentrations of HCB ranged from 1.9 to 114 mg/kg with a detection limit of 0.66 mg/kg. All detectable concentrations of HCB were verified with replicate analysis. The maximum concentration, 114 mg/kg, was 69.2 mg/kg in the replicate sample, thus the average value for this sample was less than 100 mg/kg (Olin, 1988).

Mercury in water was detected at or below the drinking water standards and ranged from 0.4 $\mu g/l$ to 2.0 $\mu g/l$. None of the organics analyzed were detected in water.

3.2 EVALUATION OF POTENTIAL PATHWAYS/IMPACTS

Under this section, the existing data were evaluated to develop a conceptual site model for Operable Units 1 and 2, describing the potential migration and exposure pathways and the preliminary assessment of human health and environmental impacts. As discussed in previous sections, Olin's McIntosh plant has been in compliance with RCRA since 1980 and has completed several reports relevant to this section. The information provided in the following sections was extracted from the 1989 RI/RA Report (ERM, 1989).

3.2.1 Identification of Pathways

Under this section, primary and secondary sources, mechanisms and migration pathways for OU-1 and OU-2 are discussed. The conceptual site models for OU-1 and OU-2 are presented in Figures 8 and 9, respectively. These models present the potential exposure to human and biota receptors resulting from release mechanisms from the potential contaminant sources at the site. The conceptual models are based on current site conditions and will be updated during the RI/FS site characterization. Summaries of the conceptual models for both units are presented below.

3.2.1.1. Operable Unit 1

The ten SWMUs closed under 40 CFR 265 are not considered primary sources because the source material has either been removed or capped. The equivalency of these closures with 40 CFR 264 requirements will be demonstrated during the RI/FS. Similarly, the other nonhazardous SWMUs and non-SWMU areas identified in Section 3.1 are also not considered primary sources. These areas have either been closed by capping, the source material has been removed, or the material is not considered a source of contamination (e.g., does not contain hazardous constituents).

The recent (pre-corrective action) and current (post-corrective action) distribution of contaminants in the Alluvial Aquifer reported by Olin have been reviewed to identify specific suspect source areas that may currently be contributing to a groundwater problem. This identification is based on an assumption that contaminant source areas will generally be proximal to or immediately upgradient of the groundwater contaminants plume center of mass. The distribution of contaminants in the Alluvial Aquifer reported by Olin from 1986 through 1989 suggests that several chemicals are concentrated in potential source areas. One potential source area, the closed weak brine pond, is located directly over portions of the area within the aquifer where the high concentrations of mercury and chlorides were observed. A second potential source area, the closed CPC landfill, may be associated with chlorides, chloroform and other chemicals. Whether these areas are continuing significant sources of groundwater contamination will be evaluated during the RI/FS (Section 5.3.2.6).

In the conceptual model for OU-1, (Figure 8) contaminated soils/sediments are considered potential primary sources, with release mechanisms of infiltration/percolation, stormwater runoff and dust/volatilization. The secondary sources included in this model are groundwater and surface water/sediments. The secondary release mechanism is infiltration/percolation to the groundwater. Pathways to be evaluated will include surface water, wind and groundwater.

The source evaluation and equivalency demonstration will be used to evaluate whether continuing primary sources do exist. Based on this evaluation, the conceptual model for OU-1 may be modified.

3.2.1.2 Operable Unit 2

Operable Unit 2 consists of the basin area, the associated wetlands and the wastewater ditch, as described in Section 3.1.2. The conceptual site model for OU-2 is shown in Figure 9. Since Olin has discharged hazardous substances in the past, and previous investigations indicate contamination of sediments. The primary sources of contamination at OU-2 are:

- Wastewater ditch and other drainageway sediment
- Basin sediment

The primary release mechanisms from the wastewater ditch and basin sediments consist of 1) overflowing of the ditch, 2) infiltration/percolation from the ditch and basin into underlying soil and groundwater, and 3) oxidation/reduction or physical release of contaminants from sediments into water bodies. Releases from primary sources may result in three secondary sources of contamination:

- Structures - Earthen dikes and nearby structures from overflow
- Soil - Surface and subsurface from all primary releases
- Groundwater - Infiltration/percolation

The secondary release mechanisms for the secondary sources identified above are stormwater runoff (over surface soil or structures that are contaminated), dust from contaminated soils and infiltration/percolation (of pore water from contaminated subsurface soils into groundwater). The secondary release mechanisms will result in pathways for potential exposure to human and biota receptors. The resulting pathways for stormwater runoff are surface water and transported sediments. The pathway for dust from contaminated soils is wind. The resulting pathway from infiltration/percolation of subsurface soils is groundwater.

3.2.2 Potential Exposure

The potential exposure for the media of concern from OU-1 and OU-2 is presented in the following sections.

3.2.2.1 Operable Unit 1

The pathways described above lead to potential exposure to human and biota populations from groundwater contamination. The maximum total population during daylight hours of a work week (i.e., during normal business hours of the Ciba-Geigy and Olin facilities) is estimated to be about 2,600 (ERM, 1989). According to this report, a total of 35 residences with domestic wells were identified within a three-mile radius of the Olin facility. The wells range in depth from 14 to 130 feet, with 15 reported to be in the 20-to-40-foot zone. Several of the residences also maintain a hookup to public water and only use well water for washing clothes, automobiles or watering lawns or gardens.

As part of the RCRA compliance activities at the plant site, Olin has identified several waste-handling facilities as SWMUs and has recognized that several of the SWMUs may have acted as source areas for contaminants detected in the Alluvial Aquifer. Olin has implemented both remedial closure actions and corrective actions to prevent migration of pollutants already in groundwater and to restore the Alluvial Aquifer.

Corrective action initiated by Olin in 1987 with approval from the EPA and ADEM consisted of installation and operation of five groundwater recovery wells with associated treatment systems. These actions have mitigated the impact of contaminants within the Alluvial Aquifer, as evidenced by the continuing development of large capture zones around the recovery wells and subsequent reduction in size of the contaminant plume relative to the pre-corrective action distribution. These data are submitted in the semiannual reports submitted to James H. Scorbrough of EPA Region IV and Don Cosper of ADEM (September 18, 1986, April 24, 1987, October 15, 1987, April 28, 1988, November 29, 1988, April 1, 1989, March 1, 1990, August 30, 1990 and February 27, 1991) under the post-closure RCRA permit.

While groundwater is the primary concern, other potential exposure routes will be investigated.

- <u>Subsurface Soils</u>

  Several areas of soils contamination on the plant site have been identified by past investigations. The distribution of contaminants observed is discussed in detail in the RI/RA (ERM, 1989). The soils within the area occupied by the CPC plant were observed to have some organic chemical contamination (S&ME, 1982).
  The closure and removal activities described in Section 3.0 were designed to prevent surface exposure and retard subsurface migration, which could lead to potential exposure routes. The RI/FS will include a source evaluation to assess whether any significant continuing sources still exist.

- <u>Surface Water and Sediments</u>

  The potentiometric contours indicate that the Alluvial Aquifer discharges to the Tombigbee River. Therefore, one potential exposure route is the discharge of contaminated groundwater to the Tombigbee and the subsequent exposure from contaminated surface water.

Potential exposure to surface water in the basin will be evaluated in OU-2. There are no other known contributing sources of surface water or sediment contamination at Operable Unit 1. Olin currently operates a regulated NPDES discharge for surface water. Discharge water quality is within the required permit limits. Additional surface water and sediment samples, if needed will be obtained during the RI/FS to evaluate the existing data, re-evaluate contamination and determine the potential for contaminant migration through a surface water pathway.

- Air

  There are no known measurable contributing sources of air contamination at Operable Unit 1. However, during the RI/FS, estimates will be performed to evaluate the potential for exposure through air pathways.

3.2.2.2 Operable Unit 2

The Operable Unit 2 area is remote from the Olin McIntosh plant and from residential areas. The area is private property and signs are posted, limiting access and recreational activities such as hunting and fishing. In 1987 Olin conducted an investigation at the basin (Olin, 1988). In that investigation, water and sediment samples were collected from ten locations. Data from this report were used to determine the media that could result in potential exposure. These media are:

- Surface Water

  Olin's 1987 investigation reported levels of mercury in basin water, ranging from 0.35 to 2.0 ppb. However, to re-evaluate these data, the work performed under this RI/FS will include additional water sampling and analysis. A phased approach is being used for conducting the RI/FS, which will provide a better understanding of the water quality of the basin and evaluation of contaminant migration through surface water pathways.

- Sediment

The previous investigation conducted by Olin reported five chemicals detected in the sediment samples. These chemicals are:

- Mercury
- 1,2-Dichlorobenzene
- 1,4-Dichlorobenzene
- Hexachlorobenzene
- Pentachloronitrobenzene

Additional sediment data will be collected to verify existing data and to re-evaluate sediment contamination and migration through sediment pathways.

- Subsurface Soil and Groundwater

Groundwater contamination could result from releases from the infiltration/percolation mechanism at this unit. No groundwater monitor well sampling is proposed initially. The hydraulic interaction between the basin and the groundwater is the major factor controlling whether there is a potential for contamination from basin sediments to infiltrate the groundwater in OU-2. Past potentiometric data indicate that the basin acts as a discharge area during non-flood conditions with flow from the groundwater to the basin. During these periods, there is little potential for contaminant migration out of the basin sediment into the groundwater. However, during periods of the year when the basin is in flood, there may be a groundwater reversal. The potential for groundwater contaminant migration in OU-2 will be assessed by evaluating historic temporal groundwater elevation data and basin elevation data to determine whether flow reversals do occur during flood, and if so, are these reversals significant enough to cause contaminant migration from basin sediment into the groundwater. If such reversals occur, a method to assess potential contamination will be proposed.

- Air

  Air contamination would result from the volatilization of contaminants from surface water. Additional exposure assessment and estimates will be performed during this RI/FS to evaluate the contaminant migration through wind.

3.2.3 Potential Impact

3.2.3.1 Operable Unit 1

Exposure to humans may occur through ingestion or dermal contact with contaminated groundwater. Although groundwater is contaminated, Olin has implemented a CAP for the Alluvial Aquifer. Therefore, the risk associated with groundwater will be reduced with continuation of groundwater remedial actions. An evaluation of quarterly monitor well data is planned, and a one-time groundwater sampling will be performed to characterize the groundwater contamination and demonstrate that the data collected previously are comparable to data collected under current CERCLA procedures. The potential impact will be further evaluated during the risk assessment portion of the RI/FS. Exposure scenarios involving contaminated soils or sediments may also be evaluated depending on the results of the characterization activities.

3.2.3.2 Operable Unit 2

Exposure to humans may occur through dermal contact, ingestion and/or inhalation. Previous air contamination estimates due to evaporation/volatilization do not indicate an air-associated risk. Since the sediments and basin water were found to be contaminated with the past releases of hazardous substances, exposure assessment and impact will be further evaluated during the risk assessment portion of the RI/FS to determine exposure to wildlife, biota, wetlands and groundwater.

3.3 PRELIMINARY IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES AND ALTERNATIVES

As part of the RI/FS process, a preliminary identification of remedial action objectives and alternatives is conducted. This preliminary evaluation is to help ensure that the data needed to evaluate the appropriate remedial action can be collected as soon as possible during the RI/FS process. Any necessary remedial actions will address both the primary and secondary sources at the site.

3.3.1 Remedial Action Objectives

The preliminary objectives of any necessary remedial actions developed for the feasibility study are to address protection of human health and environment. One underlying objective is to verify the contaminants of concern for OU-1 and OU-2. The evaluation to identify remedial action objectives will concentrate on both primary and secondary sources (groundwater and soil). The following preliminary remedial action objectives have been identified based on generalized media of concern.

REMEDIAL ACTION OBJECTIVES

Media of Concern	Human Health	Environment
Groundwater	Prevent ingestion of groundwater having contaminant concentrations in excess of maximum concentration limits (MCLs), a of cancer risk for all contaminants in excess of $1x10^{-4}$ to $1x10^{-7}$, and a	Restore contaminated potable groundwater sources to primary drinking water quality levels.

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	Hazard Index greater than 1.	
Soil (surface and subsurface)	Prevent ingestion/direct contact with soils having compounds with a cancer risk in excess of $1x10^{-4}$ to $1x10^{-7}$ and a Hazard Index greater than 1.	
Surface Water	Prevent ingestion of water having contaminant concentrations in excess of a total of $1x10^{-4}$ to $1x10^{-7}$ cancer risk and a Hazard Index greater than 1. Prevent releases from the site to off-site surface water that would cause contaminants to exceed water quality standards.	
Sediments	Prevent direct contact with sediments from the site having in excess of $1x10^{-4}$ to $1x10^{-7}$ cancer risk and a Hazard Index greater than 1.	Prevent releases from sediments that would result in contaminants in surface water in excess of surface water standards.
Contaminated Dust	Prevent direct contact with contaminated dust from the site having in excess of $1x10^{-4}$ to $1x10^{-7}$ cancer risk and a Hazard Index greater than 1.	Prevent the release of contaminated dust to be carried by wind to nearby receptors.

The objectives discussed above will be utilized as screening criteria during the evaluation of remedial alternatives.

3.3.2 Consideration of ARARs

Selection of remedial alternatives must take into consideration the Applicable or Relevant and Appropriate Requirements (ARARs). A list of ARARs and their potential applicability to remedial alternatives are presented below. This list will be expanded and refined as more information is obtained and the potential remedial actions are better defined.

3.3.2.1 Federal Clean Water Act

Water from remediation activities and other contaminated surface waters may be treated onsite. The effluent from any treatment will be tested and not discharged until the test results are below the concentrations listed in the NPDES permit.

- National Pollution Discharge Elimination System (NPDES) - These permitting requirements, found in 40 CFR Parts 122 and 125, require permits for the discharge of pollutants from any point source into waters of the United States. Under CERCLA regulations, an NPDES permit is not needed if the regulatory requirements are met. Effluent quality will meet the maximum concentrations for "Best Available Technology Economically Achievable (BAT)" for nonbiological treatment facilities or water quality standards for the receiving water body.

- Alabama National Pollution Discharge Elimination System - These state regulation's require a permit for any discharge into state waters from the McIntosh site will be regulated under an Alabama NPDES permit or permit modification. The maximum outfall effluent limits for any McIntosh clean-up operations will be existing or modified NPDES permit limits.

- Alabama Water Quality Criteria and Use Classification - Based on the location of an effluent discharge, more stringent permit limits may be imposed.

- Section 404 of the Clean Water Act - The location of a structure, excavation of wetlands or discharging dredged fill material into the waters of the U. S. or wetlands would require a permit from the Army Corps of Engineers.

3.3.2.2 Federal Clean Air Act

Requirements of this act regulate standards for emissions to the air from point sources or units. For example, if an incinerator is used for disposal of wastes offsite or onsite it will meet the criteria listed in this act, and air permits will be current and applicable to the disposal facility or the onsite unit.

- Alabama Air Pollution Control Rules and Regulations - These regulations establish specific emission concentration limits for point sources, such as incinerators or air strippers. As with the Clean Air Act requirements, any disposal or treatment method used will meet all applicable emissions criteria and will have an air monitoring plan showing how these levels will be tested. The state of Alabama will be notified prior to initiating any remediation activities which would result in air emissions.

Ambient air quality will be monitored as outlined in the project Health and Safety Plan for personal air monitoring.

3.3.2.3 CERCLA Offsite Policy

These requirements regulate the disposal of hazardous wastes generated at a Superfund, or CERCLA site. Any offsite treatment, storage or disposal facility used will have made application to the EPA Region in which it is located to substantiate conformance to provisions of the CERCLA offsite policy.

3.3.2.4 Transportation Safety Act - Standards Applicable to Transporters of Hazardous Waste

All standards or regulations required to ship hazardous waste offsite will be met by the licensed subcontractor. These regulations will include 49 CFR 107, 171-173, 177 and 40 CFR 262.30 - 262.34. All transporters will be permitted by the ADEM to haul hazardous waste.

3.3.2.5 Federal Solid Waste Disposal Act

This includes the 1976 Resource Conservation and Recovery Act (RCRA) and other amendments to the Solid Waste Disposal Act. The corresponding Alabama Hazardous Waste Management Regulations are appropriately addressed in the discussion of relevant federal regulations. The Olin McIntosh site is listed on the EPA's National Priority List (NPL) which is regulated by CERCLA, therefore, federal RCRA permits are not required.

Identification and Listing of Hazardous Waste - The handling, storage, treatment or disposal of sludges, soils, leachate or groundwater will be in accordance with all applicable State and Federal solid waste or hazardous waste regulations and policy.

Remediation activities at the McIntosh site will comply with all regulations and record keeping requirements applicable to the remediation activity.

The standards for evaluating the equivalence of past hazardous waste closure standards under 40 CFR Part 264 with closure standards presently required under 40 CFR Part 265 will be performed.

Any new hazardous waste stream which would be sent offsite for treatment or disposal would require ADEM approval priority to shipment or disposal by any TSD facility in Alabama.

Constituents in the groundwater would be compared to the drinking water standards, or background groundwater data or published public health criteria to determine levels of cleanup. For example, the maximum allowable concentration in the groundwater is 0.002 mg/l of mercury as specified in Table 1, Maximum Concentration of Constituents for Groundwater Protection of the Alabama Hazardous Waste Regulations.

Land Disposal Restrictions and Toxicity Characteristic Rule - Disposal of any waste generated during remedial action would have to comply with the land disposal restrictions and the Toxicity Characteristic Rule. In certain instances soil and debris containing hazardous waste resulting from CERCLA remedial actions/RCRA corrective actions is temporarily exempt from land disposal restrictions. However, they may be classified as a hazardous waste under the state of Alabama regulations since the ADEM did not adopt many of the land ban variances.

3.3.2.6 Occupational Safety and Health Act

Under 40 CFR Section 300.38, the requirements of this act apply to all response activities. All applicable OSHA regulations will be met at the McIntosh site. The requirements of one or more of the following regulations will be met during the different stages of the remediation or cleanup work.

29 CFR 1903.2	29 CFR 1904.2 - 1904.10
29 CFR 1910.20	29 CFR 1910.120
29 CFR 1910.132 - 1910.134	29 CFR 1910.252
29 CFR 1910.1028	29 CFR 1926.58
29 CFR 1926.59	29 CFR 1926.650 - 1926.653

The onsite health and safety officer will be responsible for ensuring that the regulations listed above are met.

3.3.2.7 River and Harbor Act (Section 10)

Any structures or work in or affecting the Tombigbee River required by the remediation would require a permit from the U. S. Army Corps of Engineers.

3.3.3 Preliminary Remedial Alternatives

Olin has already closed or clean-closed all of the hazardous waste units and covered all non-hazardous units. There are no other areas believed to be significant, continuing sources. Olin is currently remediating the principal secondary source in OU-1 (i.e., groundwater) to protect human health and the environment. The RI/FS tasks will include re-evaluation of existing data and one-time monitoring for data verification. This re-evaluation will consider the potential for the residual soil contamination to leak hazardous constituents at levels that would contaminate groundwater at greater than allowable concentrations. Preliminary remedial alternatives for OU-1 include technologies for the potential secondary sources (contaminated subsurface soil and groundwater), and also for potential primary sources in the event that they are found to be significant contributing sources during the RI activities.

In order to adequately screen potential alternatives for the conceptual primary and secondary sources, OU-2 must first be characterized. Secondly, the preliminary candidate technologies must be evaluated for their effectiveness in protecting human health and the environment.

During the RI/FS, data will be obtained through field and laboratory activities and a literature survey to evaluate the candidate technologies. The literature survey will provide an evaluation of the need for treatability testing, if appropriate.

A treatability testing work plan will be developed which will consist of the following:

- Description and background of the project
- Technology description and available data
- Testing objectives

- Testing facility and equipment
- Detailed testing procedures
- Testing parameters
- Analysis
- Data evaluation
- Report preparation

The treatability work plan is further discussed in Section 5.2.1 of this work plan. The following remedial alternatives for OU-1 and OU-2 will be considered.

3.3.3.1 No Action

This alternative will be evaluated for both operable units for the sediment/soil and groundwater media. The no-action alternative that is evaluated for OU-1 will include continuation of the existing corrective action program. Olin had initially proposed in the December 1990 draft of the Work Plan a "paper" study considering the no action alternative with the hypothetical discontinuation of the corrective action. After receipt of EPA comments on the December 1990 submittal, Olin reconsidered this approach. It was determined that the no action alternative should be evaluated with continuation of the corrective action because the corrective action program is a RCRA requirement under Olin's post-closure permit.

3.3.3.2 Contaminated Sediments

The potential alternatives for the remediation of contaminated sediments in OU-2 are discussed in the following paragraphs.

Dredging/Offsite Disposal

The sediment from the basin may be dredged and transported to an offsite treatment facility. Treatment options to be evaluated would include the following:

- Dredging methods - hydraulic/mechanical
- Onsite separation/offsite landfilling
- Offsite separation and disposal
- Offsite solidification/stabilization and landfilling
- Offsite incineration

Dredging/Onsite Disposal

The sediments may be dredged and treated onsite with a mobile treatment unit. Treatment would include those items previously presented for offsite treatment.

In-Situ Treatment

The sediments will be evaluated for in-place treatment consisting of:

- Natural sedimentation
- Dumping/grading neutral soil
- Geotextile/geomembrane or clay cap
- Solidification/stabilization/soil cap

Containment

Containment of contaminated sediments may be performed by evaluating the following methods.

Soil Capping - dam/flocculation/sedimentation
- Enhanced dam or sedimentation
- Dam or drain with clay cap
- Pumpable soil cap
- Dam or drain with liner or clay cap

Backfilling - Backfill/natural shoreline
- Dam or drain with backfill with or without solidification

3.3.3.3 Contaminated Surface and Subsurface Soil

The potential alternatives for the remediation of contaminated surface and subsurface soils from either OU-1 or OU-2 are discussed in the following paragraphs.

Excavation/Offsite Treatment

Surface and subsurface soils may be excavated and transported to an offsite treatment facility. Treatment options to be evaluated would include the following:

- Biological treatment
- Solidification/stabilization
- Chemical treatment
- Thermal treatment
- Soil washing

Excavation will be evaluated based on use of standard excavation equipment.

Excavation/Offsite Disposal

The surface and subsurface soils may be excavated and transported directly to an offsite disposal facility. Offsite disposal options would include:

- Offsite incineration
- Offsite landfilling

The offsite disposal facilities must be approved by EPA to accept CERCLA wastes.

Excavate/Onsite Treatment

The surface and subsurface soil may be excavated and treated onsite with a mobile treatment unit. Treatment options would include those previously presented for offsite treatment.

Excavate/Onsite Disposal

The surface and subsurface soils may be excavated and disposed onsite. Onsite disposal will be evaluated based on both single and multiple disposal sites. Disposal options will consist of onsite landfilling of the soils or onsite incineration (with onsite landfilling of ash).

In-Situ Treatment

The surface and subsurface soils will be evaluated for in-place treatment consisting of:

- Solidification/fixation
- Biological treatment
- Chemical treatment
- Soil venting
- Vitrification
- Soil Washing (flushing)

Containment

Containment of contaminated surface and subsurface soils may be performed by capping in place. Capping may consist of soil covers with or without synthetic liners to prevent the infiltration of surface water into the underlying soils.

Other forms of containment may include vertical barrier walls consisting of slurry walls, sheet piling, and/or grout injection.

3.3.3.4 Groundwater

Groundwater is the media of concern in OU-1. A corrective action program has been implemented. However, additional alternatives for recovery and treatment or containment of contaminated groundwater are presented here for consideration during the RI/FS.

The contaminated groundwater at the site may be controlled by either containment (restriction of areal migration), recovery and treatment or a combination of technologies. Alternatives for containment of the contaminant plumes are:

- Barrier systems (slurry walls, cut-off walls, etc.)
- Extraction and hydraulic control systems (lowering of water table, pumping, etc.)
- In-situ treatment technologies

Groundwater recovery and treatment may be accomplished by any of the following alternatives:

- Recovery alternatives
    - direct pumping
    - interceptor trenches

- Treatment
    - chemical/biological oxidation
    - biological
    - membrane separation
    - UV photolysis
    - carbon absorption or multi-media
    - air stripping
    - volatilization/evaporation
    - aeration

4.0
WORK PLAN RATIONALE

The primary objectives of the RI/FS are:

- To investigate the nature and lateral and vertical extent of contamination at the site (waste types, concentrations and distributions) for all affected media including air, groundwater, soil, surface water and sediment, including confirmation of the results of previous investigations. The lateral and vertical extent of contamination will include any offsite migration resulting from the entire site.

- To refine and expand the results of the previously submitted Baseline Risk Assessment to assess the current and potential risk to public health, welfare, and the environment.

- To develop and evaluate alternatives for an appropriate remedial action to prevent or mitigate the migration, release or threatened release of contaminants from the site.

This work plan is designed to provide the basis for accomplishing these objectives. The work plan rationale (basic framework) consists of the two following basic elements:

- Data Quality Objectives (DQOs) (the qualitative and quantitative requirements of the data)

- Work plan approach (the way in which the data will be obtained to meet the data quality objectives)

The following paragraphs present a detailed description of each of these elements.

4.1 DATA QUALITY OBJECTIVES

As stated in previous sections, Olin believes that OU-1 at the Olin site has been characterized. Section 3.1 summarizes the SWMU and non-SWMU areas that have been identified as past potential contaminant sources in OU-1. These areas have either been closed, decommissioned, the source material has been removed, or the material is not considered a source (e.g., the ash ponds). In addition, in 1987, Olin initiated a RCRA Corrective Action Program (CAP) consisting of five groundwater recovery wells with associated treatment systems. The recovery wells are all screened in the Alluvial Aquifer. Since the CAP has been in place, contamination of groundwater has been observed to have decreased at the RCRA compliance boundaries (ERM, 1989). The present RI/FS will include an evaluation of the extensive information that is already available for OU-1, with emphasis on verifying existing data.

Operable Unit 2 has been less extensively studied. The RI/FS activities for OU-2 will be directed towards characterization of this unit.

The RI/FS will target groundwater sources in OU-1 along with an evaluation of soils and sediments as continuing significant sources. OU-2 activities will concentrate on surface water and sediment sources. The activities will be performed simultaneously for both operable units. The data quality objectives will be centered on the contamination sources discussed above and identification of potential pathways and impact to receptors.

The general RI/FS data objectives will be as below:

- The data will be obtained as stipulated in this work plan and the Sampling and Analysis Plan (SAP). The SAP will consist of the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP).

- The data will take into consideration ARARs. The ARARs are summarized in Section 3.3.2.

The data will also meet analytical quality assurance objectives (i.e., suitable for evaluation after data collection). The proposed analytical methods presented in the SAP have been reviewed to verify that methods will provide detection limits that are adequate for data evaluation and use in risk analysis.

To satisfy the objectives of the RI/FS, there are several specific data requirements. These are listed below, along with the operable unit that requires the data:

- Evaluation of existing information and site reconnaissance data, (OU-1 and OU-2)
- Groundwater characterization data, (OU-1 and OU-2)
- Domestic well survey and sampling, (OU-1)
- Surface water and sediment sampling data, (OU-2)
- Bathymetric survey data, (OU-2)
- Vegetative stress survey data, (OU-2)
- Macroinvertebrate study data objectives, (OU-2)
- Fish sampling data, (OU-2)

These data requirements are described in more detail in the following sections.

4.1.1 Evaluation of Existing Information and Site Reconnaissance Objectives

Extensive historical site studies regarding topography, hydrogeology, geology, local vegetation and biota, local land use, demographics and population density have been conducted and reported in several technical memoranda appended in Betz and Converse (1977) and in subsequent environmental investigations. These data will be re-evaluated and updated.

For OU-1, historical aerial photographic and topographic information will be studied to locate any additional potential sources, migration pathways, or potential receptors that were not previously identified. EPA has provided Olin with aerial photographs, and preliminary work regarding evaluation of these photographs has already begun. Numerous investigations have been conducted to define the areas of soil and groundwater contamination. These existing data will be reviewed to confirm that significant primary sources in OU-1 have been mitigated through the closure and removal activities described in Section 3.1. The existing groundwater sampling data from the RCRA quarterly sampling events (37 wells for 14 sampling events) will be used to define the nature and extent of contamination and to verify migration pathways. Groundwater characterization is discussed in 4.1.2. These data as well as soil data generated during closure and any additional soil data that are required will also be used to demonstrate the equivalency of past RCRA closures to 40 CFR 264 requirements.

For OU-2, a review of historic topographic information will be emphasized to determine past drainage patterns to the basin and thus provide a basis for the basin characterization. Again, a preliminary evaluation has already begun on the aerial photographs that were provided by EPA. Available data regarding the local biota will also be reviewed to provide a basis for subsequent evaluations on the potential effects of basin contamination. A site reconnaissance and site survey will be conducted to verify and update the existing data on OU-2.

4.1.2 Groundwater Characterization Data Objectives

As stated in Section 2.0, two aquifers are of concern at the Olin McIntosh site: the Alluvial Aquifer and the Miocene Aquifer. There is documented contamination in the Alluvial Aquifer. Limited data collected six to nine years ago indicate that the Miocene may contain low levels of contamination (see Table 2). Additional data will be collected to confirm whether contamination exists in the Miocene.

The contaminants of concern detected in the groundwater are mercury, volatile organic compounds, and base/neutral compounds. Chloride is also present and has been used as an indicator of the contaminant plume. Potential sources of these contaminants have been identified from the extensive RCRA monitoring program (1986 through 1989) at the site. Olin believes that the extent of contamination of the Alluvial Aquifer has been characterized. Additionally, Olin believes the contaminant plume has been delineated and the surface/subsurface pathways of migration have been identified. Olin has instituted a Corrective Action Program for OU-1 and the program has been in operation since August, 1987.

Groundwater characterization will focus on the following major objectives:

- An evaluation of the occurrence of constituents in the Miocene Aquifer.
- An evaluation of past and current groundwater data to determine whether the characterization of contamination in the Alluvial Aquifer is complete (i.e., the chemical constituents have been defined; the lateral extent has been defined and the migration pathways have been identified). The lateral limits of the plume will be based on wells that consistently show chloroform concentrations less than 50 μg/l and mercury at concentrations below the detection limit of 0.4 μg/l.
- An evaluation of the effectiveness of the ongoing corrective action program.
- An evaluation of the potential for constituents to migrate from the surface water and sediments to the groundwater in OU-2.

In order to confirm the direction of groundwater flow and the migration pathways in OU-1, water elevations will be obtained from all 113 monitor wells at the facility. (Figure 3 shows the well locations.) Based on these water elevation measurements a potentiometric contour map showing groundwater flow directions will be generated.

Olin has six active process water wells screened in the Miocene Aquifer. A minimum of two of these wells pump at all times at an approximate rate of 1000 gpm each. The effects of the pumping will be evaluated using an analytical model based on the Theis equation and the reported values for transmissivity and storativity. The results of this model will be compared to measured drawdowns in the Miocene Aquifer and possibly refined based on these measurements. The results will be used to show the produced cones of depression to define the Miocene Aquifer groundwater flow direction within the plant area. These interpreted groundwater flow patterns will provide data regarding the effectiveness of the one time sampling of selected Miocene Aquifer wells described below (e.g., are the Miocene wells selected for sampling downgradient of areas of contamination observed in the overlying Alluvial Aquifer), and also be used to assess whether additional Miocene monitor wells should be installed and/or sampled. Any additional Miocene monitor wells would be double cased to prevent downward contaminant migration. Any well installation or additional sampling activities would be outlined in a revised SAP.

Olin's Post-Closure RCRA permit (September 1986, modified in September 1988) requires a compliance monitoring program and a corrective action monitoring program at the facility. Olin samples a total of 37 monitor wells on a quarterly basis. These monitor wells were specified based on their relationship to the Closed Weak Brine Pond (closed unit wells) and other former RCRA units (compliance point wells). The locations of the wells and SWMUs are shown on Figure 10. This program will continue and the data evaluated in conjunction with the other groundwater characterization activities under the RI/FS. The available boring logs and well construction details for these wells are presented in Appendix B. Table 6 summarizes the well construction details. Historical trends in the quarterly monitor well data will be evaluated by plotting time vs. concentration graphs (clean-up curves) for each of the 37 wells, and isoconcentration maps will be generated for each quarterly monitoring event. These quarterly monitor well data will be used for both groundwater characterization and the source evaluation activities described in Section 5.3.2.6. The Tombigbee River stage will be compared to on-site potentiometric data for each of the sampling events to evaluate the potential for groundwater contamination in OU-2 (see Section 5.3.1.2).

As part of this RI/FS, selected monitoring, corrective action, and water wells will be sampled and the water will be analyzed for the parameters listed in the QAPP. This will be a one-time sampling event. The information obtained from the sampling event will be used in conjunction with the quarterly monitor well data to confirm that the nature and extent of groundwater contamination has been adequately characterized and resolve any interpretive questions regarding sources and fate (e.g., the high organic concentrations detected about 2300 feet west of the CPC Plant). Additionally, the sampling results will be used to determine whether the data collected under Olin's groundwater detection, assessment and corrective action programs are equivalent to data collected under current CERCLA standards. Data obtained from one-time sampling may also be used in demonstrating the equivalency of 40 CFR Part 265 closures with 40 CFR Part 264 closure requirements.

Sample collection and handling will be conducted in general accordance with EPA approved procedures as defined by the EPA Engineering Support Branch Standard Operating Procedures (SOPQAM) (EPA, 1986) and close QA/QC surveillance. Sample analysis will be performed by the sampling and analytical methods that are described in the SAP.

4.1.3 Domestic Well Survey and Sampling Objectives

To adequately characterize the risk associated with OU-1, the domestic wells within a three-mile radius will be identified. Any drinking water wells that are identified will be sampled and analyzed for site-specific parameters and drinking water quality parameters. Access to domestic drinking water wells will be dependent on the owner's permission. These data will be utilized for subsequent assessment of potential receptors to site contaminants.

4.1.4 Bathymetric Survey Data Objectives

A bathymetric survey will be conducted in the basin. A bathymetric survey is a measurement of water depth, and will be used to characterize the bottom configuration of the basin. This survey will assist in determining sample locations along sampling transects and in making subsequent interpretations regarding the depositional history of the basin. The information obtained from this survey will be integrated with aerial photographs and topographic maps to produce an interpretive map showing the basin morphology and any identified depositional features (e.g., abandoned stream channels).

4.1.5 Sediment Sampling Data Objectives

A review of previous investigations as summarized in ERM (1989) has shown that available data are insufficient to fully characterize OU-2. Therefore, sediment sampling will be conducted to define the lateral and vertical extent of sediment contamination in the basin, adjacent wetlands, and the associated ditches. The basin and associated ditches are well defined topographic/hydrographic features whose boundaries constitute a logical limit for the initial characterization of OU-2. Therefore, the basin and its associated ditches will be investigated first along with potential pathways outside the boundaries of OU-2. If the extent of contamination has not been determined by investigating the basin area, the investigation will be extended in the direction(s) in which additional data are required, which may include the adjacent Tombigbee River. Any additional investigation activities would be outlined in a revised SAP.

Sediment samples will consist of both core samples and surface sediments. Core samples will be obtained at selected locations within the basin. The objective of the core sampling is to evaluate the occurrence of contamination with depth, and define the vertical extent of contamination. Grab surface samples will be collected from the basin and the associated ditches. These samples will be obtained at locations based on an established grid to define the lateral extent of contamination. Other areas may also be sampled based on a review of the topographic maps and aerial photographs. The bathymetric survey may also indicate additional areas for sampling (localized high or low areas not intercepted by the grid).

4.1.6 Surface Water Sampling Data Objectives

Surface water samples will be collected from the water bodies in OU-2. Surface water samples will be obtained from randomly selected locations in the basins, and from each of the ditches that contain water. When there is sufficient water depth (greater than 3 feet) the samples will be obtained from discrete intervals. The surface water sample results will provide data on the lateral and vertical distribution of contaminants in the basin water and water in the associated ditches. The data will also be used to evaluate the potential impact to human and biota receptors from exposure to basin water.

4.1.7 Macroinvertebrate Study Data Objectives

A macroinvertebrate study in conjunction with a vegetative stress survey (Section 4.1.8) and fish sampling program (Section 4.1.9) will be conducted to assess the effects of contaminants on the basin ecosystem. The composition and diversity of macroinvertebrate communities in contaminated areas (as indicated by sediment sampling) will be compared with those of communities in control areas. Control areas will be determined after initial characterization of the basin. The sampling will provide a detailed characterization of the macrophyte and aquatic macroinvertebrate communities of the basin under nonflood conditions. The basic information on taxonomy and numbers of individuals plants and benthic macroinvertebrates observed or collected per unit of effort will be reported as well as resulting indices calculated for use in comparisons. This survey will provide information regarding potential pathways to human and other biotic receptors and provide data for the subsequent evaluation of potential remedial alternatives.

4.1.8 Vegetative Stress Survey Data Objectives

As a part of the effort to assess the effects of local contamination in the basin on the biota, a vegetative stress survey will be conducted. This survey will focus on the vegetative cover and wetlands in the vicinity of OU-2.

Since a current biological inventory of the basin and connecting bodies of water and/or wetlands is unavailable, the vegetative stress survey will consist of the following tasks:

- Characterization of the principal macrophytic plant communities.
- Survey of indications of stress, if any, to vegetation with particular reference to the distribution of contaminants in surface water and sediments.

The vegetation study phase will consist of a biologist identifying and mapping the principal plant communities in OU-2 based on a review of aerial photographs and a field survey. The data obtained from this review will aid in providing qualitative and quantitative descriptions of the plant communities. A species inventory for the study area will be prepared, with an identification of the endangered plant species. The methodology for conducting the study is presented in detail in the SAP.

Upon completion of the vegetation study, a survey will be conducted to identify aberrations in vegetative cover in the study area. Any abnormal variations in tree populations, species, physical characteristics, etc., will be documented as possible evidence of stress. To the degree possible, identification of the extent to which these effects have resulted specifically from the presence of contaminants, as opposed to other associated effects, such as habitat disruption, will also be identified.

4.1.9 Fish Sampling Data Objectives

The 1987 fish sampling program described in Section 1.3 was limited in scope and therefore conclusions were not made regarding the effects of basin contamination on fish species. Any fish sampling program must be designed to account for the fact that the basin is contiguous with the Tombigbee River five to six months a year. Therefore, any fish sampling program will be oriented toward fishes indigenous to the basin and will minimize the effects of fish migration between the basin and the Tombigbee River.

Selection of fishes for any sampling program will be based on the following specific criteria:

- Sampled fishes will be predacious sport fishes and bottom-feeding, bottom-dwelling species. In essence, both types of fishes should represent "worst case" scenarios. Predacious sport fishes represent the upper trophic levels or the top of the food chain and as such should exhibit any tendency to bioaccumulate or biomagnify any contaminants in the system. The bottom-feeding, bottom-dwelling species represent fishes whose life histories, behaviors, and food habits place them in closest physical contact with bottom sediments.

- Both human health and ecological considerations will be taken into account when selecting the fish species for sampling.

- Sampled fishes will represent species most likely to be indigenous to the basin. Thus the focus of sampling will be on lacustrine (lake-dwelling) fish species and particularly those inclined toward minimal migratory movements. Lotic or riverine (river-dwelling) species will be avoided whenever possible. In spite of such precautions, it is recognized that fish captured in the basin may have spent at least part of their lives in the river environment. That factor must be considered when interpreting the analytical results.

The aforementioned criteria will focus sampling on target species in order to yield optimal and valuable information. The planned restriction of tissue sampling to fishes likely to represent "worst-case" concentrations will provide a basis for describing or estimating the extent of contamination. In light of the desire for expeditious completion of the RI/FS, it is reasonable to limit the scope to characterizing the extremes and then estimating the potential levels in other components of the food web. This estimate will be a qualitative narrative of the presence and movement of the contaminants in the aquatic food web. To minimize the confounding factor of migration as much as possible, Olin plans to sample fish that are less likely to engage in large-scale movements. Accordingly, largemouth bass (Micropterus salmoides) and either yellow or black bullhead (Ictalurus natalis or I. melas) are designated as the preferred species to sample, if available in sufficient quantity. The former is a predacious species which tends to be relatively sedentary (particularly the older, larger individuals). Largemouth bass represent the top of the aquatic "food chain," and provide the additional advantage of being a favored sportfish. Use of this species will thus provide a good basis for estimation of both ecological and human risk. The bullheads are bottom-dwelling, bottom-feeding omnivores which will provide an excellent indication of the significance of intimate contact (through food ingestion and gill ventilation) with the sediments. Bullheads are believed to be less migratory than other Ictalurus, such as the channel catfish. Although occasionally eaten by humans, bullheads provide a particular advantage from the ecological risk perspective because they are common prey of piscivorous reptiles, birds, and mammals. In the event that reasonable sampling efforts fail to yield the specified minimum number of individuals for each species (20), alternative species will be selected on the basis of the same criteria noted above. Possible acceptable alternatives to largemouth bass are envisioned as warmouth (Lepomis gulosus) or black crappie (Pomoxis nigromaculatus).

Olin also proposes to address additional considerations as part of any fish sampling program. Those considerations are as follows:

- Sampling will be conducted on free-swimming, feral fishes from throughout the basin.

- Filets will be analyzed separately from each individual fish for total mercury and selected organic compounds. Further analyses will be performed on selected samples to provide whole-body concentrations. The filets represent the portion of the fish most likely to be consumed by humans. The whole body analyses will provide insight into potential ingestion-pathway exposures to wildlife.

- Adequate statistical design and sufficient sample sizes are critical to generating valid, interpretable data. A sample size of twenty individuals of each selected fish species was selected based on the characterization of variability in fish, professional judgment and experience. Five of the 20 individuals of each species will be analyzed further to provide "whole body results."

Sampling of feral fishes has the advantage (over cage studies) of representing the "real world" situation by utilizing free-ranging specimens. However, this approach has the disadvantage that some captured specimens may have spent portions of their lives in the Tombigbee River and thus would not completely represent conditions in the basin.

Electrofishing, hoop netting, and other gear appropriate to desired species will be employed to capture fishes. A preliminary electrofishing survey will be conducted in conjunction with the Phase I bathymetric studies to verify the availability of the preferred species for sampling. Detailed fish sampling methodologies and protocols will be submitted to EPA in a revised SAP.

4.1.10 Additional Objectives

Data obtained from each aspect of operations will be evaluated to determine the need for additional detailed investigation (e.g., additional work outside the boundaries of OU-2). If further data are needed, additional activities will be implemented. Any additional work may require modifications/addenda to the various project plans (Work Plan, SAP, HSP, etc.). These modifications will be incorporated as approved by EPA.

Specific data quality objectives as described above are also addressed in the Quality Assurance Project Plan (QAPP) of the SAP. The data quality objectives will be accomplished during the implementation of the work plan in conjunction with the SAP.

4.2 WORK PLAN APPROACH

The work plan approach consists of the data collection program needed to meet the data quality objectives described in Section 4.1. The work plan approach for OU-1 and OU-2 is presented below. Details of the work elements are described in Section 5.0.

4.2.1 Operable Unit 1

As stated in previous sections, OU-1 has been characterized and extensive data are available. The RI/FS will generally consist of evaluating existing data and verifying that the data are adequate and meet data quality objectives (DQO) and current CERCLA standards. Therefore, the work plan approach for data collection will consist of a single phase that will include the following evaluation and verification activities.

- Evaluation of existing data and aerial photographs
- One-time sampling of existing wells
- Survey and sampling of domestic wells

- Equivalency demonstration of 40 CFR 265 closures with 40 CFR 264 requirements.
- Source evaluation
- Additional activities

These activities are described in more detail in Section 5.3.

4.2.2 Operable Unit 2

Operable Unit 2 includes the basin, the wetlands within the Olin property line, and the wastewater ditch leading to the basin. The basin is a well-defined topographical hydrographic (and hence ecologic) feature whose boundaries constitute a logical limit for the initial characterization of OU-2. Data collection will be conducted in two phases during this initial characterization to meet the objectives outlined in Section 4.1. Phase I will include:

- Evaluation of existing data
- Bathymetric survey
- Sediment sampling
- Surface water sampling

Phase II activities in OU-2 include the following:

- Vegetative stress survey
- Macroinvertebrate survey
- Fish sampling
- Sediment sampling

These activities are intended to provide characterization of ecological conditions in the lowland basin, indication of possible stress in two major groupings of sedentary organisms (rooted macrophytes and aquatic macroinvertebrates), and the "worst-case" concentrations of contaminants in the aquatic food chain. Because of the limited time for field work during this initial characterization (see next paragraph), the media to be measured and/or sampled were chosen to provide information of maximum potential value for estimating ecological and human risk, as well as for evaluating remedial alternatives. As a river floodplain, the basin is subject to dynamic physical factors due to the varying river stage. Strategic indicator parameters as indicated in this Work Plan and SAP will be measured to provide a basis for assessment of potential risks and evaluation of appropriate methods of remediation.

The scheduling of the basin characterization activities is critical. Aquatic biological sampling (i.e., macroinvertebrates and fish) cannot begin until details of the bathymetry of the basin and the distribution of contaminants in sediments are established to provide for a better informed determination of sampling locations. The bathymetric survey and sediment/water sampling will be initiated as soon as water in the basin has receded to nonflood levels. The OU-2 sampling will be confined to the nonflood period, during which the basin is semi-isolated, for the following reasons:

1. With less water and turbulence (i.e., less dilution/dispersion) the likelihood of encountering "worst-case" contaminant concentrations increases.

2. With shallower and less turbulent water, sampling will be more efficient (e.g., lower turbidity enhances electrofishing success).

3. Conditions will be less hazardous for personnel.

The window of non-flood conditions is approximately five to six months and both Phase I and Phase II will have to be completed in this time frame. The Phase I data will be used to develop a revised SAP. This plan will include the details of the fish sampling procedures and the planned locations for sampling macroinvertebrates. Additional core/sediment samples will also be collected during Phase II to assess "hot spots" identified in Phase I, and conduct discrete depth (each 2-inch interval) analysis of the bioaccessible zone (upper 6 inches of the sediment). The site characterization activities outlined above are designed to provide for an evaluation of the basin and its associated ditches as well as the potential pathways outside the boundaries of OU-2, including the adjacent Tombigbee River. The results of the basin investigation will be presented in the Preliminary Site Characterization Summary which is scheduled to be submitted on April 1, 1992. If the lateral and vertical extent of contamination has not been determined by the investigation of the basin area and its associated ditches, the investigation will be extended in the direction(s) in which additional data are required and additional activities would be outlined in a revised SAP.

5.0
RI/FS TASKS AND SUBTASKS

The RI/FS generally consists of the following major tasks:

- Task 1: Planning and preparation of work plans
- Task 2: Community relations
- Task 3: Field investigation/site characterization
- Task 4: Baseline risk assessment
- Task 5: Treatability investigations (if applicable)
- Task 6: Development and screening of remedial action alternatives
- Task 7: Analyses of alternatives
- Task 8: Remedial Investigation (RI)/Feasibility Study (FS) Final Report

An overall RI/FS approach model is presented in Figure 11.

5.1 TASK 1: PROJECT PLANNING AND PREPARATION OF WORK PLAN

Task 1 involves project planning and development of work plans. A continuous aspect of the RI/FS is project planning. As each task is implemented, continual planning must be conducted to evaluate the direction of the RI/FS. Due to the flexibility of this work plan, frequent communications between the EPA and Olin must occur.

As part of the Consent Order, project meetings and periodic progress reports are also required and are fully discussed under each task described in subsequent sections. Project planning has already been initiated in the development of the Consent Order. During implementation of the RI/FS, intermediate tasks will be evaluated to determine if changes in scope are required for performing the risk assessment or to evaluate potential alternatives.

5.1.1 Communications and Reporting

Communications between site personnel and EPA personnel (both site and non-site), if any occur, will be documented in writing via meeting notes, telephone logs, or log books. Summaries of such communications will be included in the progress reports described below.

The following summarizes the submittals that are required as part of Task 1:

Submittal	Description	Copies EPA	Copies ADEM
Work Plan	A comprehensive description of the work to be performed, the media to be investigated, the methodologies to be utilized and the rationale for selection of each methodology. A comprehensive schedule is also to be included.	15	2
Field Sampling Plan (FSP)	Field sampling objectives, methods, location, frequency, sampling equipment, and sample handling and analysis and documentation.	15	2
Quality Assurance Project Plan (QAPP)	Outlines QA/QC procedures for field, office and laboratory activities.	15	2
Health and Safety Plan (HSP)	Health and safety site requirement and spill control/volatile emissions contingency plan.	15	2
Progress Report	Monthly reports that (1) describe the actions which have been taken toward achieving compliance with this Consent Order during the previous month; (2) include all results of sampling and tests and all other data received by Respondent during the course of the work, excluding data previously submitted;	1	2

(3) include all plans and procedures completed under the Work Plan during the previous month; (4) describe all actions, data, and plans which are scheduled for the next month, and provide other information relating to the progress of the work as deemed necessary by EPA; and (5) include information regarding percentage of completion, unresolved delays, encountered or anticipated, that may affect the future schedule for implementation of the Scope of Work and/or RI/FS Work Plan, and a description of efforts made to mitigate those delays or anticipated delays. These progress reports will also be required during subsequent RI/FS tasks.

5.2 TASK 2: COMMUNITY RELATIONS

As required by the Consent Order, a Community Relations Plan for the entire project will be developed by the EPA. The plan will be developed based upon the guidance "Community Relations in Superfund."

The objectives of community relations during the RI/FS process are to: 1) inform the public of the purpose of the project, 2) educate the public on the RI/FS and remedial process, and 3) preclude potential conflicts resulting from lack of information.

5.3 TASK 3: SITE CHARACTERIZATION

The overall objective of site characterization is to describe areas of the site that may pose a threat to human health or the environment. The geology and hydrogeology of the McIntosh site have been characterized by Olin. Information including the physiography, demography, ecology, waste characteristics, and engineering properties of the soils was obtained during previous investigations conducted at the site and is summarized in Section 2.0.

Olin believes that the nature and extent of groundwater contamination in OU-1 has been characterized. Similarly, the surface and subsurface migration pathways were defined in the RI/RA Report (ERM, 1989). The contaminant plume was delineated and a corrective action program has been in-place since August, 1987. All of the identified sources were addressed as a part of various closure and removal activities described in Section 3.0. Consequently, site characterization for OU-1 will consist of a review of available information and sampling of existing wells to confirm that the past data are equivalent to data collected under current CERCLA standards.

OU-2 has been less extensively investigated and more detailed site characterization will be conducted. Site characterization will include sampling of sediments and surface water and evaluating the effects of contamination on the local biota.

The site characterization subtasks for OU-1 and OU-2 are as follows:

- Evaluation of Available Data
- Site Characterization Activities
- Laboratory Analysis/Validation
- Data Reduction and Evaluation
- Data Management
- Communications and Reporting

These subtasks are described in more detail in the following sections.

5.3.1 Evaluation of Available Data

5.3.1.1 Operable Unit 1

Due to the extensive data available for OU-1, this subtask is an important aspect of site characterization. The following work elements are proposed for evaluating the data available for OU-1:

- A study of historical aerial photographs and identification of any additional sources or pathways for the migration of contaminants. This will generally consist of a review and interpretation of aerial photos already provided to Olin by EPA.
- An evaluation of current land use and regional site environs.
- A survey of domestic wells located within a three-mile radius of the site.
- A review of groundwater chemical data from monitor wells sampled during the corrective action program to evaluate the character and extent of groundwater contamination, and the occurrence of significant continuing sources of groundwater contamination.

The above proposed work elements are designed to define additional potential sources of contamination, if any, contributing to the releases previously identified in OU-1. Further, the scope of work proposed above will refine the conclusions made previously with regard to the nature and extent of contamination and contaminant fate and transport in OU-1.

If a modeling effort is considered appropriate after evaluating the additional data in conjunction with the existing data, the plan for models will be submitted to EPA as a technical memorandum.

5.3.1.2 Operable Unit 2

The evaluation of available data for OU-2 will consist of reviewing historical aerial photographs and topographic maps. The objective here will be to identify important topographic features such as tributaries to the basin (past or present) and to aid in the interpretation the basin depositional history. This evaluation will help in determining the various areas to be sampled, if any, in subsequent phases. Available historical data regarding water quality in the basin will also be reviewed. The available information on the local biota will be reviewed to provide a basis for the subsequent assessment of basin contamination.

During the data review, an assessment of the potential for groundwater contamination in OU-2 will be conducted. Specifically, the river stage of the Tombigbee, hence the basin elevation, will be compared to potentiometric data from each of the quarterly sampling events (a total of 14 events) from comparable dates. This comparison will be used to evaluate whether flow occurs from basin sediments to groundwater.

5.3.2 Site Characterization Activities

This section details the site characterization activities required to meet the RI/FS objectives. These activities were developed in Section 4.0 and some of the work items involve field data collection and evaluation of existing data. Since the work is being conducted in a phased approach, with certain aspects of the field investigation dependent on data evaluation activities, certain evaluation work elements are also described here with the field activities.

Olin will initiate field support activities following approval of the Work Plan and Sampling and Analysis Plan (SAP). Olin will notify EPA at least two weeks prior to initiating any field support activities so that EPA may adequately schedule oversight tasks. Further, Olin will notify EPA at least two weeks in advance of the field work regarding the planned dates for field activities in both of the aforementioned operable units. Olin will also notify EPA in writing upon completion of field support activities. The field activities proposed for OU-1 include the following:

- Site Reconnaissance to verify existing data.
- A one time sampling of selected monitoring, corrective action and water wells.
- A domestic well survey
- If any drinking water wells are located within a three mile radius of the site, sampling at these wells for site specific parameters and drinking water quality parameters.

The field activities proposed for OU-2 include the following:

- Bathymetric survey of the basin to map the bottom configuration.
- Sampling and analysis of basin sediments on a grid and at incremental depths at selected locations to determine the lateral and vertical extent of contamination.
- Sampling of sediments and surface water from the wastewater ditch, the former flow path from the wastewater ditch to the basin, and the current flow path from the wastewater ditch to the basin.
- Sampling of sediments along the discharge ditch, where the basin discharges into the Tombigbee River.
- A vegetative stress survey to assess potential ecological impacts.
- A macroinvertebrate study in the basin to assess potential impacts on these organisms. Any impacts will be determined by comparing diversity indices and species composition in contaminated areas to those of control areas.
- Fish sampling and analysis of selected species in the basin.

Olin will consistently document the quality and validity of field and laboratory data compiled during the Remedial Investigation. At a minimum, these will include the following activities:

- Documenting field activities through well maintained field logs and laboratory reports in a manner consistent with the procedures in the SAP.
- Maintaining sample management and tracking. Olin will maintain field reports, sample shipment records, analytical results, and QA/QC reports to ensure that validated analytical data are reported and utilized in the development and evaluation of the Baseline Risk Assessment and Remedial Action Alternatives. Analytical results will be accompanied by a corresponding QA/QC report. In addition, Olin will establish a data security system to safeguard chain-of-custody forms and other project records to prevent loss, damage, or alteration of project documentation.

5.3.2.2 OU-1: Site Reconnaissance

After evaluation of existing data as described in Section 5.3.1, a site reconnaissance will be conducted as part of Phase I to evaluate current physiographic features. This site reconnaissance may include obtaining additional topographic information to verify existing topographic data and to document any changes that may have occurred (e.g., changes in drainage pathways). Existing wells have been surveyed for location and elevation since the December 15, 1991 submittal of the Work Plan. The newly established well survey data will be used during the RI/FS.

5.3.2.3 OU-1: Groundwater Sampling

Water levels will be measured in 113 monitor wells to define the potentiometric surface as described in Section 4.1.2. Groundwater sampling under this RI/FS will be conducted on selected monitoring wells as discussed in the SAP. The scope of this RI/FS will be to conduct a one-time sampling of selected monitoring wells, Miocene Aquifer, and CAP wells located in OU-1 to verify the results of previous investigations and verify that data are comparable to data collected under current CERCLA standards. The wells selected for sampling are presented in the SAP. The selected wells will be sampled and analyzed for the following constituents as specified in the EPA Contract Laboratory Program (CLP): Mercury (total and dissolved), additional Target Analyte List (TAL) compounds; Target Compound List (TCL) Volatile Organics; TCL Semi-Volatile Organics; TCL Pesticides/PCBs, and Chloride. The subset of the Target Analyte List (TAL) includes the thirteen metals on the Priority Pollutant List and cyanide. These include:

arsenic
cadmium
chromium
lead
mercury
nickel
selenium

silver
antimony
beryllium
copper
zinc
thallium
cyanide

This proposed parameter list will adequately characterize the occurrence of potentially hazardous analytes, while excluding those constituents on the TAL that are not considered hazardous, but can be found in varying concentrations naturally in the soils, sediments and groundwater. The analytical protocols will be in accordance with the QAPP as approved by EPA.

5.3.2.4 OU-1: Domestic Well Survey and Sampling

Residential drinking wells within a three-mile radius of the site will be surveyed. Initially, a survey will be conducted to identify all domestic water wells within the target radius. Previous surveys (BCM, 1978) have identified a total of 35 domestic wells in an approximate three-mile radius. The study has stated that not all of these wells are being used for drinking water purposes. The proposed survey will consist of a review of records, a mail out of questionnaires, and a phone survey. A door-to-door survey will be conducted of the residences that are not reached by mail or telephone. After the survey, any identified drinking water wells with potential exposure from the site will be sampled for total mercury, selected organics based on sampling in onsite monitor wells, TOC, TDS, TSS, and Chloride. Access to the domestic drinking water wells will be dependent on the owner's permission.

5.3.2.5 OU-1: Equivalency Requirements

The demonstration that Olin's closure of RCRA units under 40 CFR 265 is equivalent to closure under 40 CFR 264 will be conducted in accordance with EPA guidance. Olin will submit to EPA previous Appendix VIII groundwater data and a map showing the relationship of the wells from which these data were generated to SWMUs. After reaching an agreement regarding the use of these data and after completing the source evaluation, the specific activities to be conducted for the equivalency demonstration (i.e., a description of any sampling activity parameters to be analyzed, etc.) will be presented to EPA for approval. Since Olin has generated considerable amounts of data during the original closure activities, these data will be used to support the equivalency demonstration. As part of this task, the relevant data will be reviewed and an equivalency demonstration report will be prepared for EPA review and approval. The general aspects of the equivalency demonstration are provided below:

- Unit Description - This will provide information on the size and location of the unit, the wastes managed by the unit (e.g., waste type and quantities), liner system, leachate collection, containment, and run-on and runoff control systems. This will also include hydrogeology of the immediate area, groundwater and soil conditions, groundwater monitoring systems, detection programs and any corrective action activities undertaken.

- Description of Closure Activities - The description of closure activities conducted will identify, in detail, all removal and decontamination activities completed at the unit during closure. This description will include information on the quantity of waste removed (by waste type), the quantity of leachates and contaminated containment liquids removed, the quantity of bottom sludges/residues removed, the quantity of contaminated soil removed, the methods used for removal of inventory (i.e., waste, sludge, residue, liquid, and soil), and the procedures used for decontaminating and/or disposing of inventory. Specifically, the description of the decontamination and disposal activities will identify the method of decontamination equipment/structures, the treatment or disposal of cleaning agents/rinse water, and the demolition and removal of containment systems (e.g., liners, dikes) and other equipment/structures.

- Demonstration of Compliance - The demonstration of compliance with Clean Closure Levels, will present sampling data supporting the equivalency demonstration. This section will specify where samples were taken in each relevant medium, when the samples were taken, what parameters were examined, and the analytical results. The information will specify the sampling protocols and analytical methods used during the sampling activities, along with variable quality assurance/quality control information. The raw sampling data will also be submitted for review. In cases where proxies are used, a full explanation of the reason and assumption will be included.

- Conclusion and Enclosure - A summary of major information included in the above section will be presented in this section. A copy of the closure certification will be enclosed along with all the raw data and relevant documents.

5.3.2.6 OU-1: Source Evaluation

The occurrence of potential continuous significant sources will be evaluated by reviewing the quarterly monitor well data from the RCRA Corrective Action Program (37 wells and 14 sampling events). These data will be plotted on concentration versus time graphs. Historical trends in the quarterly monitor well data will be evaluated by plotting time vs. concentration graphs (clean-up curves) for each of the 37 wells, and isoconcentration maps will be generated for each quarterly monitoring event. The approach is that if significant continuing sources do exist, the presence of these sources should be reflected in the groundwater data, either in the lateral distribution (i.e. the plume is not diminishing as was predicted in the modeling efforts) or the clean-up curves show an increasing or non-diminishing trend. In addition, the review of historical photographs for potential source areas will also be included in the source evaluation. This review has already begun based on aerial photographs and interpretations provided by EPA. The source evaluation will be submitted to EPA in a technical memorandum and will require EPA approval.

5.3.2.7 OU-1: Additional Tasks

Data obtained from each work element will be evaluated as they are obtained to determine if additional data are required. For example, if data from the sampling of the selected wells and the evaluation of the quarterly monitor well data indicate that the lateral extent of groundwater contamination is not completely defined, another task may be added to sample and/or install additional wells. If the source evaluation indicates that significant continuing sources exist, soil sampling tasks may be added. Also, if during the risk analysis, it becomes apparent that additional data are required, another activity may be performed to acquire the data. The potential additional work may require modifications or addenda to the project plans (RI/FS Work Plan, SAP). These modifications will be submitted for EPA approval at the time that the need for additional work is identified.

5.3.2.8 OU-2, Phase I: Bathymetric Survey

A bathymetric survey of the basin will be conducted during Phase I. This survey will consist of developing transects in both the north-south and east-west directions and determining water depths at specified intervals along these transects. The aim of this survey will be to define the bottom configuration of the basin, and in conjunction with other data, develop interpretations on the basin depositional history.

5.3.2.9 OU-2, Phase I: Sediment Sampling

Core sediment samples will be collected at three sample locations from the 1987 basin investigation (Olin, 1988) (Figure 7). The two locations that indicated the highest mercury concentrations (SC and SF), and the one location with the highest detected hexachlorobenzene concentration (SA) will be cored. Core depths and sample intervals will be based on field conditions (e.g., thickness of sediment, percent recovery in core, etc.). However, a 6-inch interval is anticipated. In addition to the core sampling, grab surface samples will be collected on a grid established at approximate 200-foot spacing across the basin. The wastewater ditch, discharge ditch (sampling location to be set in field with EPA approval), the former flow path from the wastewater ditch to the basin, and the current flow path from the wastewater ditch to the discharge ditch will be sampled every 200 feet along the centerline. These will also be grab-type samples. Additional samples may also be collected based on topographic features of the basin bottom defined by the bathymetric survey (e.g., localized high or low areas), and depositional history interpretations from the evaluation of topographic maps and aerial photographs. All samples will be split and analyzed for total mercury.

In addition to the total mercury analysis, selected split core samples and grid samples will be analyzed for soluble mercury, pH, Total Organic Carbon (TOC), sulfide/sulfate, the selected list of TAL constituents, TCL Volatile Organics, TCL Semi-Volatile Organics, and Pesticides/PCBs. The TOC, sulfide/sulfate analyses will provide data on the mobility, fate and transport of the constituents in the basin. The remaining samples will be refrigerated and protected from light until the above analyses are completed. The results of the CLP analyses will be used to identify appropriate indicator contaminant(s) to define the organic contamination in the basin. The grid samples and additional core will then be analyzed for the selected organic indicator contaminant(s). Olin proposes to develop an appropriate laboratory analytical technique to screen for the indicator contaminant(s) that are identified, which may be a field laboratory technique. This technique will be verified by comparing the screening results to replicate samples of the grid samples and the cores that were analyzed by CLP protocols. The SAP provides more details of the Phase I sampling.

5.3.2.10 OU-2, Phase I: Surface Water Sampling

Surface water samples will be collected at ten randomly selected grid locations in the basin. Surface water samples will also be obtained from each of the drainages to the basin that contain water. If the water depth is greater than 3 feet at the selected sample location, the water samples will be obtained from discrete intervals in the water column (a maximum of three samples per location). The sampling procedures are discussed in more detail in the SAP. The water samples will be analyzed for mercury (total and dissolved), the selected list of other TAL constituents, TCL Volatile Organics, TCL Semi-Volatile Organics, TCL Pesticides/PCBs, Dissolved Oxygen (DO), pH, TOC, Total Suspended Solids (TSS), and Total Dissolved Solids (TDS).

5.3.2.11 OU-2, Phase II: Vegetative Stress Survey

A vegetative stress survey will be conducted by a qualified botanist. The survey will include evaluation of the influence of localized topographic features (e.g., ditches, levees, meander scars, etc.) on vegetative community structure. This consideration will assist in interpreting apparent indications of stress, by accounting for differences attributable to elevation or slope versus those which may be related to contaminants. The indicators of stress (either due to contaminants or other factors) could be browning of a patch of grass, trees with dry leaves and drooping branches, etc. Such areas will be identified and marked on maps for further evaluation as to the potential causes of the stress.

5.3.2.12 OU-2, Phase II: Macroinvertebrate Study

Based on the results of sediment and water sampling, a study of aquatic macroinvertebrates in the basin and associated ditches and tributaries will be undertaken to assess potential impacts on these organisms. The basic information on identification and enumeration of macroinvertebrates observed or collected per unit of effort will be reported as well as the resulting indices calculated for use in comparisons. The impacts will be evaluated by comparing the composition and diversity of macroinvertebrate communities in contaminated areas (as indicated by sediment sampling) with those of communities in control areas.

5.3.2.13 OU-2, Phase II: Fish Sampling

Tissues from fish species representing both the top of the aquatic food chain as well as the bottom-dwelling, bottom-feeding existence will be sampled and analyzed for mercury and selected organic contaminants. The criteria for the selection of fish species to be sampled is presented in Section 4.1.9. In addition to the sampled fishes, the identities and catches per unit effort of fish taken during sampling for tissue will be recorded to provide information on the basin fish communities under nonflood conditions.

5.3.2.14 <u>OU-2, Phase II: Sediment Sampling</u>

Phase II sediment sampling will be conducted after receipt of the chemical analyses from Phase I activities. Phase II will consist of collecting additional cores at "hot spot" locations in the basin and/or drainageways. The locations and vertical intervals of the cores will be based on the Phase I results. Discrete depth analysis will also be conducted from selected sediment cores to evaluate the bioaccessible zone.

5.3.2.15 <u>OU-2, Additional Tasks</u>

The basin is a well-defined topographic/hydrographic (and hence, ecological) feature whose boundary constitutes a logical limit for initial characterization activities. Olin has made a commitment to evaluate the basin and its associated ditches as well as evaluate potential pathways outside the boundaries of OU-2, including the Tombigbee River. Olin is further committed under this RI/FS to delineate the lateral and vertical extent of contamination. If the extent of contamination has not been determined by the investigation of the basin area, Olin will extend the investigation in the direction(s) in which additional data are required.

The results of the activities outlined above will be presented in the Preliminary Site Characterization Summary (SCS). The details of any subsequent phase of investigation will be included in a revised Sampling and Analysis Plan.

5.3.3 Laboratory Analysis/Validation

The analytical protocols to be followed for analytical testing of samples from the site (with the exception of the laboratory screening method) shall be in accordance with EPA Contract Laboratory Program procedures or EPA Statement of Work 846 methods, 3rd Edition. Complete analytical protocols and analytical QA/QC requirements are addressed in the SAP.

Before any results are reported, data validation will be completed in accordance with "Laboratory Data Validation Functional Guidelines for Evaluating Organics Analysis," dated February 1, 1988. The validation process will be conducted independently from the laboratory performing the analytical work. The complete data packages will be sent on an analytical lot basis to validation personnel.

Specific data validation procedures will be developed for each analytical method as a standard operating procedure. These procedures will be followed for all samples analyzed and the results will be summarized in a report for each lot of reported sample data. Unusable data will not be reported. However, qualified data will be reported as such and the appropriate qualifiers will be utilized in the report. The following is a brief description of the methods that will be used in the data validation for laboratory data.

1. A list of all investigative samples will be compiled.

2. A list of all QC samples will be compiled, including but not limited to:
   - Field blanks
   - Trip blanks
   - Laboratory blanks
   - Laboratory duplicates
   - Performance samples
   - Matrix spikes
   - Matrix spike duplicates
   - Laboratory control spikes and laboratory control spike duplicates

3. Chain-of-custody documents will be reviewed for completeness and correctness.

4. Laboratory analytical procedures and instrument performance criteria will be reviewed. This review will include:
   - Sample holding time
   - Instrument performance
   - GC/MS tuning and performance

- Blanks
- Surrogate recovery
- Matrix spike/matrix spike duplicate
- Compound identification
- Compound quantification
- System performance
- Overall assessment of data for a case

5. A data summary will be prepared. It will include:
   - Validated results
   - Sample media identification
   - Sample location and descriptions
   - Proper concentration units
   - Proper significant figures

   This data summary will be reviewed for potential data quality problems including:
   - Unexpected results
   - Common laboratory contaminants
   - Unusual spacial concentrations/identification relationships

As stated, actual details of the validation process will be addressed in the Quality Assurance Project Plan (QAPP) (as part of the SAP), and will be in accordance with EPA requirements.

5.3.4 Data Reduction and Evaluation

As data are obtained, they will be reviewed, reduced and evaluated to determine the objectives previously outlined. Data evaluation will be an ongoing continuous process, which may result in changes to the scope of work (i.e., work plan, SAP). New data from the RI will be evaluated in conjunction with existing site data to verify that all the necessary data have been compiled. If not, additional site characterization may be performed.

5.3.4.1 Site Characteristics

New and existing data on physical characteristics will be analyzed to describe the environmental setting at the site. The environmental setting will include surface features, soils, geology, hydrology, and hydrogeology. This information will be utilized in determining contaminant fate and transport for various pathways of exposure.

5.3.4.2 Source Characteristics

Primary and secondary sources of contamination at the site have been conceptually defined. The RI activities will address the sources and will also evaluate the effects of the existing CAP. The actual and potential magnitude of further releases or residuals after the CAP has been implemented will be evaluated, as well as the mobility and persistence of any remaining contaminants.

5.3.4.3 Nature and Extent of Contamination

The data from RI activities will be analyzed (along with existing data) to further describe the degree of contamination at the site. The areal extent of the contamination will be evaluated to define transport pathways. The areal and vertical extent of contamination (in soil, groundwater, or surface water) will be evaluated to perform the risk assessment, as well as to develop the remedial alternatives (and the extent of remediation).

5.3.4.4 Contaminant Fate and Transport

Results of the previous three activities (site characteristics, source characteristics, and nature and extent evaluations) will be compiled and evaluated to establish contaminant fate and transport. Existing data on contaminant releases may be used to help assess rate of migration in each pathway and the fate of contaminants during the period of releases and monitoring. Depending upon the need, models may also be used in determining fate and transport descriptions and in screening remedial alternatives. However, actual field data will be used to the extent possible.

5.3.5 Data Management

Due to the extensive amount of information that will be generated, a data management system consisting of field activity documentation, sample tracking and records management will be implemented.

It is anticipated that various activities will be assigned unique task numbers such that data may be readily retrieved for a specific activity. In addition, phase numbers will also be utilized as a means for tracking the documents by activity and/or time.

5.3.5.1 Field Activities Documentation

Documentation of field activities will be detailed in the SAP, as part of the Quality Assurance Project Plan (QAPP). The documentation requirements will generally consist of the following:

- Daily Field Reports. These reports will be written in bound log books or standardized log forms and, as a minimum, will include changes to project plans, field measurements (pH, temperature, conductivity, etc.), observations and sample locations. The log book will consist of consecutively numbered pages. Each day's entries will be properly headed with date, time, phase and task, project number, etc., and completed with date and signature.

- Standard Information Forms. These records will provide summary information, such as a sample collection log, accident report, groundwater sampling report, boring logs, etc. Forms of this nature will be cross-referenced in the daily reports and, along with daily reports, will be retained in the permanent files.

- Chain-of-Custody. These records will originate in the field at the time of sample collection (as outlined in the SAP/QAPP) and will be fully executed until returned from the laboratory following analysis. Copies of the chain-of-custody records from the field will be retained for the permanent files until replaced with the fully executed copy that is returned from the laboratory.

- Sample Analysis Request Forms. These forms will be originated in conjunction with the chain-of-custody forms and will be used to instruct the analytical laboratory of the desired analysis. As with the chain-of-custody forms, the request forms will be copied and eventually replaced with the original form for permanent record-keeping.

In addition to the permanent records file for all original documents, copies of field data, along with the project plans, drawing, etc., will be kept onsite at a designated office space. These records will be kept in a secured facility, with restricted access to the files.

5.3.5.2 Sample Management

Due to the extensive sampling efforts required to perform the RI/FS, a detailed sample management program will be implemented. The current Paradox data management system, for the site which includes field sample data, analytical results, water level data, and well construction details, will be expanded to include all addition data collected during the RI/FS. Additional types of data (e.g., bathymetric survey data, fish sampling data, etc.) will be added to the data management system as they are collected. As part of the data validation process (Section 5.3.3), sample tracking will be performed. As each set of data are validated, the analytical results will be transferred to a computerized database management system. The data will be stored by type (i.e., groundwater, soil, etc.), data collected, analysis, identification number (field and laboratory), phase and task. This system will enable retrieval of information specific to various interests since it will be input into various fields (as described above). The data may be graphically presented in the form of maps or figures. Sample management is further detailed in the QAPP (of the SAP).

5.3.5.3 <u>Document Control and Inventory</u>

In addition to field documentation the scope of documents related to the project will include, at a minimum, the following:

- Project plans
- Submittals (i.e., progress reports, summary reports, project reports)
- Meeting notes
- Memorandums
- Drawings
- Laboratory data

Documents will be permanently filed in a secured facility with access restricted solely to project personnel. Documents will be filed by project number, phase and task, and category (field data, lab data, submittals, etc.). Subcategories will be established where necessary (for example, submittals may be subcategorized into progress reports, plans, summary reports, etc.). Each document will be issued a unique document number and a file log will be maintained to track all documents for the project. Controlled documents, such as project plans, will be uniquely numbered for distribution and a separate distribution log for controlled documents will also be maintained. In addition, project photographs, plans, and specifications will also be uniquely numbered and separate maintenance logs will be retained. Copies of field-related data, project plans and drawings will also be retained onsite for reference. An up-to-date file index will be submitted to EPA periodically at its request.

5.3.6 Communications and Reporting

A summary of the submittals during the site characterization is as follows:

Submittal	Description	Copies EPA	Copies ADEM
Technical memorandum on source evaluation.	Evaluation of quarterly monitor well data to assess whether trends indicate significant continuous sources exist.	5	2
Technical memorandum on modeling (if appropriate)	Based on site characterization data a memorandum will be prepared describing groundwater flow or contaminant transport modeling effort, if appropriate.	5	2
Preliminary Site Characterization Summary (SCS)	A summary report describing field activities and results. Also, a preliminary evaluation.	15	2
Revised SAP	Detailed methodologies and protocols for implementation of a fish sampling program and any additional investigation.	15	2
Draft Remedial Investigation (RI) Report	Summary of RI activities, analytical and study results, an evaluation of contaminant, identification of sources, fate and transport.	15	2

The final version of these reports will incorporate agreed upon EPA, discussions, comments, recommendations and suggestions. Each of the submittals presented above will be a comprehensive, stand-alone document, in that all backup information, including test results and calculations, will be included. If during the course of the RI/FS process additional data are required, the EPA will be notified in the form of a memorandum within 20 days of identification of the need for the data. Additionally, if unanticipated or changed circumstances arise which may conflict with the project plans or require modification to the plans, the EPA will be notified within 48 hours of discovery of the situation.

5.4 TASK 4: BASELINE RISK ASSESSMENT

The Baseline Risk Assessment presented in the previously submitted RI/RA Report (ERM, 1989) will be refined and expanded based on additional data acquired through the planned RI activities. The risk assessment will be carried out for OU-1, OU-2 and migration pathways off-site to the Tombigbee River. An evaluation of the potential threat to human health and the environment with no further remedial action will be performed. This evaluation, or risk assessment, will first determine if further remedial action is required, provide the justification for such a decision and determine to what extent remedial action is required. The data to be used for the risk assessment will be continually evaluated during the course of the RI to determine if additional data are required.

In order to attain the objectives of the baseline risk assessment, the following data are required:

- Applicable or Relevant and Appropriate Requirements (ARARs), established guidelines, and advisories.
- Toxicity and concentrations of contaminants present in relevant media (soil, sediment, groundwater and surface water).
- Environmental fate and transport mechanisms within specific environmental media.
- Potential human and environmental receptors.
- Potential exposure routes and current extent of exposure.
- Extent of future threat and probability of such threat.
- Levels of uncertainty for all of the above.

The risk assessment process is divided into four components:

- Contaminant Identification
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization

The relationship between the four components is presented on a model in Figure 12. The overall approach of the risk assessment will be in accordance with EPA's Risk Assessment Guidance for Superfund (OSWER 9285.7-01A) and Exposure Factors Handbook.

5.4.1 Contaminant Identification

The information obtained during the RI activities and existing data will be used to identify the contaminants of concern at the site and to subsequently identify indicator contaminants or those of most concern based on their degree of presence, persistence, mobility, etc. This identification will begin during the initial phases of field work. The remediation alternatives will be evaluated to verify that the alternatives will address the risks from the contamination at the site.

5.4.2 Exposure Assessment

An exposure assessment will be performed to identify additional pathways of exposure (both actual and potential) resulting from RI activities. This information will be used to characterize potentially exposed populations and the extent of exposure by identifying the transport mechanisms, point of contact and exposure route. Upon evaluating the RI and existing data, it may become evident that additional data are required. The additional data would be obtained during additional phases of the RI activities.

Upon completion of exposure pathway analysis, the actual potential for exposure will be evaluated. This evaluation will include a survey of area usage (residential, recreational, etc.) future usage of the area, and a reasonable maximum exposure scenario. This information will be compiled and an estimate will be developed of expected exposure levels.

5.4.3 Toxicity Assessment

The toxicity assessment will be performed to evaluate the types of adverse health or environmental effects associated with the individual and multiple chemical exposures, relationships between magnitude of exposure and subsequent effects, and related uncertainties. The information will be developed based on available data (literature survey) from documented studies.

5.4.4 Risk Characterization

A health risk characterization will be performed using a computer spread sheet format. The exposure concentration, route of intake and health risk will be calculated for each indicator chemical. Two different health risks will be determined, the lifetime cancer risk and the "Hazard Index." The hazard index is a measurement of combined non-carcinogenic toxicity for the mixture of chemicals. A baseline risk assessment report will be submitted to EPA and will be incorporated into the RI report.

5.4.5 Communication and Reporting

A summary of submittals during Task 4 is as follows:

Submittal	Description	Copies EPA	Copies ADEM
Technical memorandum listing hazardous substances and indicator parameters.	Identification of contaminants of concern based on presence, persistence and mobility.	5	2
Technical memorandum describing exposure scenarios and fate and transport models.	Identification of potential and actual exposure pathways and contaminant fate and and transport.	5	2
Technical memorandum providing and Environmental Evaluation.	Identification of potential environmental risks associated with the site.	5	2
Baseline Risk Assessment Chapter of RI Report.	Comprehensive description of the components of the risk assessment, source identification, uncertainty, pathways and exposure.	5	2

5.5 TASK 5: TREATABILITY INVESTIGATIONS

As site information is obtained during the RI activities, additional data that may be required will be identified during the intermediate data evaluations. The purpose of the additional data will be to provide further site characterization or information to evaluate treatability processes for remediation. Treatability studies will be performed primarily to achieve the following:

- Provide sufficient data to comprehensively develop and evaluate treatment alternatives and support a detailed remedial design.
- Reduce cost and performance uncertainties of potential alternatives.

The decision for performing treatability investigations will generally follow the following process:

- Define data requirements for potential treatment alternatives (through literature surveys and information from vendors).
- Review existing site characterization data and compare data required to data available.
- Evaluate data to verify quality objectives are met.

Treatability testing will be performed only if sufficient data are not available or there are uncertainties concerning the implementability of the techniques after the literature is reviewed. Treatability testing, if required, will be performed to evaluate a specific technology for performance, cost, implementability, ability to meet data quality objectives, and time requirements. If treatability tests are performed, a further evaluation will be performed to determine the scale of testing (bench or pilot). If appropriate, bench scale testing or pilot testing will be implemented (for well-developed technology, previously tested).

The treatability investigation consists of the following subtasks:

- Work plan preparation: The development of the detailed methodologies to be used to conduct the treatability studies. The treatability work plan is discussed in more detail in Section 5.5.1.
- Additional sampling and analysis (if required): Additional sampling and analysis may be required to better define the requirements of the treatability testing.
- Evaluation of previous studies and/or test results: In some cases, data may be available from previous studies or tests on similar media and constituents. These data should be evaluated prior to conducting the treatability test.
- Bench tests or pilot tests: This activity includes the actual testing that is conducted. The testing will generally be designed to simulate the remedial alternatives that are to be evaluated.
- Report preparation: After completion of the treatability testing, a final report will be prepared documenting the testing rationale, procedures and the results.

5.5.1 Treatability Test Work Plan

Once the decision for treatability testing has been made, a detailed work plan will be developed to define the extent of testing. The work plan will be developed specifically to respond to the requirements of the data and provide a feasible remedial alternative. The work plan will address the following:

- Description and background of project
- Technology description and available data
- Testing objectives
- Testing facility and equipment
- Detailed testing procedures
- Testing parameters
- Analysis
- Data evaluation
- Report preparation

Depending upon the complexity of the treatability study, the work plan may result in a revision to this RI/FS work plan or a separate document.

5.5.2 Application of Results

Following the treatability testing, results will be evaluated and interpreted to determine the technology's effectiveness, estimated cost, implementability and reliability. The information will be utilized such that a detailed analysis and selection of alternatives may be performed.

5.5.3 Communications and Reporting

The reporting requirements for the treatability investigation are as follows:

Submittal	Description	Copies EPA	Copies ADEM
Technical memorandum identifying candidate technologies	Identification of media requiring remediation, and potential candidate technologies	10	2
Treatability Study Work Plan (or amendment to original work plan)	See Section 5.5.1	10	2
Treatability Study Sampling and Analysis Plan (SAP) (or amendment to original plan)	Scope and methodology of sampling and analysis required for implementation of treatability study, to include QAPP revision	10	2
Treatability Study Evaluation Report	Evaluation of test results based upon screening criteria and data objectives	10	2

5.6 TASK 6: DEVELOPMENT AND SCREENING OF REMEDIAL ACTION ALTERNATIVES

This task will be performed in conjunction with treatability investigations and some subtasks will actually occur before any treatability investigation subtasks. As data are developed during the RI activities, a continual evaluation will be performed to develop potential remedial alternatives for various media at the site. The alternatives for remediation will be developed by identifying potential technologies and assembling combinations of technologies into alternatives.

The alternative development process is graphically presented on Figure 13. Generally, this process will consist of the following:

- Develop remedial action objectives based on results of the RI data, ARARs and the baseline RA.
- Develop general response actions for each medium.
- Identify extent to which the response actions will be applied.
- Screen technologies and eliminate those that do not meet the objectives or are not feasible or implementable.
- Identify and evaluate process options of each technology to select a representative process for further evaluation.
- Combine technologies into alternatives to present a range of options.

The subtasks for alternative development and screening are as follows:

- Identify remedial action objectives
- Develop general response actions
- Definition of areas and volume of media for response action
- Develop potential alternatives
- Screen alternatives
- Communication and reporting

Each of the subtasks are discussed in subsequent sections. Remedial action objectives will be established and presented as a memorandum to EPA following submittal of the RI report. Within 60 days of receiving EPA comments on this memo, a screening results memorandum will be submitted identifying the media volumes, the technology types and processes that were screened, results of the screening, and remedial alternatives to be analyzed.

5.6.1 Remedial Action Objectives

Preliminary remedial action objectives will be defined based upon the contaminants of concern, exposure routes and pathways, the acceptable concentration or ranges for each exposure route, and the potential receptors. Thus actual concentration limits will be determined for cleanup levels based upon results of the risk assessment and extent of remedial action.

5.6.2 General Response Actions

Response actions will be developed to meet the response objectives of the project. Since there is no immediate threat to human health and environment, no emergency response is anticipated. However, if Olin is required to address any immediate residual contamination removal, a technical memorandum will be provided for EPA approval before implementation.

5.6.3 Definition of Response Action

After developing the general response action based on the remedial action objectives. A more detailed definition of these response actions is required. This includes defining the areas and, the volumes of the difference media for this action.

5.6.4 Alternative Development Process

As general response actions are developed, various technologies will be identified for each response action. Once the technologies have been identified, process options within the technology will also be identified. Preliminary technologies and process options are presented in Section 3.3.2. The various process options for each technology will be researched and screened for effectiveness, implementability and cost and to eliminate those options which are not applicable to the site. A second screening will be performed to reduce the number of potential process options such that representative processes are identified for each technology. These representative processes will be evaluated and based on implementation, cost and effectiveness. The options will then be combined into various alternatives.

5.6.5 Alternative Screening Process

Upon assembly of preliminary alternatives, the alternatives will be screened similar to the screening for process options. This screening will be performed to reduce the number of alternatives to be comprehensively evaluated. Once the alternatives have been screened, those not eliminated will go through a detailed analysis to further evaluate the alternatives with respect to the general response objectives and other site-specific requirements. The screening and evaluation process is presented in Figure 14.

5.6.6 Communications and Reporting

The required reporting for the treatability investigation is as follows:

Submittal	Description	Copies EPA	Copies ADEM
Technical Memorandum Documenting Revised Remedial Action Objectives	Presentation of established remedial objectives based on RI results	5	2
Technical Memorandum on Remedial Technologies, Alternatives, and Screening	Summary of action objectives, identification of media, volumes, and technology types and processes. Results of screening and identification of remedial alternatives to be analyzed	5	2

5.7 TASK 7: DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

Upon completion of alternative development, screening and any treatability investigations, a detailed analysis of the alternatives will be performed. The analysis will consist of evaluation based upon CERCLA requirements and remedial response objectives. The process for analysis is described below.

Detailed analysis consists of the following subtasks:

- Better define remedial alternative
- Define evaluation criteria
- Perform detailed analysis
- Perform comparative analysis
- Select an alternative
- Reporting

5.7.1 Definition of Alternative

During the screening process, the alternatives that are evaluated generally are combination of technologies that may be appropriate for the site. After the number of alternatives is reduced by comparative analysis, a better definition of the selected alternatives is required. This includes a consideration site specific conditions and the general response objectives for the site.

5.7.2 Evaluation Criteria

In addition to the established remedial action objectives, the alternatives will be evaluated with respect to the following criteria:

- Overall protection of human health and environment
- Compliance with ARARS
- Long-term effectiveness
- Short-term effectiveness

- Implementability
- Cost
- State agency acceptance
- Community acceptance
- Reduction of toxicity, mobility or volume

5.7.3 Detailed Analysis

A detailed analysis of each potential alternative remaining after alternative screening will be performed with respect to the criteria presented above in addition to the remedial action objectives. The alternatives will be studied on an individual basis to assess the extent to which the alternatives meet the remedial action objectives and evaluation criteria. A summary chart of the detailed alternative analysis is presented on Figure 15.

5.7.4 Comparative Analysis

Following the individual, detailed analysis, a comparative analysis will be performed to assess performance of the alternatives in relation to each other. This will result in the identification of advantages and disadvantages for each alternative. It will also define the maximum extent to which any of the criteria may be met, thereby identifying potential tradeoffs and also assisting in the decision-making process.

5.7.5 Communications and Reporting

The following submittals are required for Task 7:

Submittal	Description	Copies EPA	Copies ADEM
Draft Feasibility Report	Documentation of development of alternatives, screening, evaluation, and analysis. Also presents preferred alternative and basis for selection	15	2

5.8 TASK 8: REMEDIAL INVESTIGATION (RI)/FEASIBILITY STUDY (FS) FINAL REPORT

After the receipt of approval from the EPA of the draft Feasibility Study Report, the Final FS Report will be bound with the Final RI Report and submitted to EPA as one document.

6.0 SCHEDULE

The anticipated overall RI/FS schedule is presented in Figure 16. The schedule is based on the submittals specified in the Consent Order. This is a very aggressive and optimistic schedule given the scope and complexity of the project. Achieving this aggressive schedule will required that all activities, both by Olin and the EPA, are completed within the time frames that are shown. It will also require that sufficient time is available (approximately 5 months) to complete the basin field activities during the non-flood season of 1991. This schedule assumes that the remedial alternatives that are identified will consist of basic technologies, and that treatability investigations, if any, will be minimal. If this is not the case, the performance period of the treatability investigation task will have to be expanded to be completed either concurrently with the feasibility study or after the draft feasibility study has been submitted. Should modifications to the scope of RI/FS tasks occur, the anticipated schedule will also require revision.

7.0
PROJECT MANAGEMENT

7.1 PROJECT ORGANIZATION

Due to the complexity of this project, several persons will be required to perform the tasks required by this work plan. An overall project organization chart is presented on Figure 17. This figure presents the management of each phase of the project. The actual tasks are performed by the staff listed below under the direction of the management indicated on the organization chart,

The project organization chart shown in Figure 17 provides for the following:

- Clear identification of lines of communication and coordination
- Monitoring of project schedules
- Management of technical resources
- Health and safety
- Quality Assurance/Quality Control.

The EPA and Olin project coordinators, as defined by the Consent Decree, are responsible for overseeing and implementation of the Consent Order. The WCC project director has the overall responsibility for WCC's work.

The WCC RI/FS project manager will be responsible for providing the overall project management, coordination and quality control. He will work in close communication with Olin and EPA project coordinators in implementing the work plans. The WCC project manager is also the site characterization manager, responsible for the implementation of the site characterization activities.

The remedial alternative task leader is responsible for developing the feasibility section of the RI/FS report. The QA/QC and data manager is responsible for ensuring the technical and procedural accuracy of the work effort. He will plan, organize and schedule field audits to ensure conformance with the plans. The Risk Assessment Manager will be responsible for the human health risk assessment. The ecological assessment manager will be responsible for the biological aspects of the project, and developing the environmental evaluation (ecological assessment) section of the Baseline Risk Assessment.

The field operations task leader is directly responsible for execution of all field activities conducted in support of the Site Characterization program and for ensuring that these activities are carried out in strict compliance with the project plans.

The peer reviewer/technical advisor will be responsible for providing technical advice in the preparation of project deliverables and a quality control review of the project deliverables.

The health and safety manager will be responsible for health and safety activities and ensuring conformance with the Health and Safety Plan.

7.2 STAFFING

Resumes of the key personnel, as presented on the organization chart, are presented in Appendix C of this work plan. Support staff who will work under the direction of the group managers will have the experience required to perform the required tasks.

8.0 REFERENCES

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TABLES

FIGURES

3 4 0C1 84

TABLE 1

SUMMARY OF 1986 FISH SAMPLE RESULTS

Species	Sample No.	Length (cm)	Weight (g)	CB[1,2] (mg/kg)	Lipid (%)	Hg[1,2] (mg/kg)
Largemouth Bass	020	35.5	712.3	0.1	0.15	1.9
Largemouth Bass	010	30.2	374.3	0.1	0.08	1.5
Largemouth Bass	005	23.6	163.3	0.1	0.12	1.5
Largemouth Bass	016	16.0	49.8	0.2	0.20	IS
Channel catfish	009	37.0	334.4	0.2	0.16	0.7
Channel catfish	018	23.5	91.6	0.6	0.26	0.7
Channel catfish	008	17.1	31.7	0.1	0.15	IS
Channel catfish	014	14.6	18.6	0.2	0.67	IS
Mullet	002	35.7	631.6	2.2	3.30	0.1
Mullet	001	35.6	530.2	3.8	3.36	0.2
Mullet	004	36.5	576.3	2.0	2.41	0.1
Mullet	007	33.0	383.3	1.8	0.92	0.2
Mullet	012	29.5	258.8	4.2	2.32	0.2
Smallmouth buffalo	006	36.3	601.0	0.2	0.27	0.6
Rockbass	003	20.0	129.8	0.2	0.30	1.0
Redear sunfish	019	16.1	54.9	0.0	0.10	IS
Redear sunfish	017	15.8	55.1	0.1	0.21	IS
Green sunfish	023	14.1	47.3	0.1	0.17	IS
Green sunfish	011	16.5	56.6	0.1	0.45	IS
Bluegill	013	16.4	63.8	0.2	0.65	IS
Bluegill	021	15.5	55.7	0.0	0.09	IS
Bluegill	015	17.0	84.7	0.2	0.51	0.8
Bluegill	022	13.8	38.0	0.2	0.27	IS

NOTES:

CB = Sum of the chlorinated benzenes; dichlorobenzene (two isomers), trichlorobenzene (three isomers), tetrachlorobenzene (two isomers), pentachlorobenzene, hexachlorobenzene, and pentachloronitrobenzene.

IS = Insufficient sample for analysis.

1 = The fish were collected in September 1986 and stored frozen until they were processed in December 1988 to January 1989.

2 = Analyses were conducted on fish filets.

TABLE 2

SUMMARY OF MIOCENE SAMPLING RESULTS

Well Number	Sampling Date	Parameter	Concentration (µg/l, unless otherwise indicated)
DH-1	08/26/82	Chloroform	3 B
		Trichloroethylene	9 B
		Chlorobenzene	<1 B
		Toluene	6 B
		Benzene	4 B
		Other VOA	ND_1
		1,2-dichlorobenzene	<10
		Pentachlorobenzene	<10
		Other B/N	ND_{10}
		Mercury	0.2
		Chloride	347 mg/l
	08/27/85	VOA	ND_1
		Mercury	0.5
		Chloride	77 mg/l
	12/03/85	Butyl benzyl phthalate	7.7
		Other B/N	ND_5
	12/05/85	1,2-dichlorobenzene	8.2
		Other VOA	ND_1
		Mercury	0.6
		Chloride	56 mg/l
DH-2	08/25/82	Chloroform	8 B
		Trichloroethylene	9 B
		Chlorobenzene	2 B
		Benzene	3 B
		Other VOA	ND_1
		1,2-dichlorobenzene	11
		1,4-dichlorobenzene	43 B
		Other B/N	ND_{10}
		Mercury	$ND_{0.1}$
		Chloride	282 mg/l
	08/25/83	Mercury	0.8
		Chloride	317 mg/l
		VOA	ND_{10}
	04/84	Mercury	$ND_{0.1}$
		Chloride	67 mg/l
	06/22/84	Chlorobenzene	7.8
		1,2-dichlorobenzene	16.9

TABLE 2 (Continued)

SUMMARY OF MIOCENE SAMPLING RESULTS 3 4 00186

Well Number	Sampling Date	Parameter	Concentration (μg/l, unless otherwise indicated)
		1,4-dichlorobenzene	16.4
		Chloride	63 mg/l
	09/20/84	Mercury	$ND_{0.1}$
		Chloride	50 mg/l
		Methylene chloride	5.5
		Chloroform	3.3
		Other VOA	ND_1
	11/14/84	Mercury	$ND_{0.1}$
		Chloride	2469 mg/l
		Chloroform	2.3
		Other VOA	ND_2
	03/12/85	Methylene chloride	1.5
		Chloroform	1.6
		Mercury	0.2
		Chloride	55 mg/l
		Other VOA	ND_1
	06/06/85	Mercury	0.2
		Chloride	84 mg/l
	10/15/85	Mercury	$ND_{0.1}$
		Chloride	7 mg/l
		Trichlorofluoromethane	1.1 (ND_1 in dup)
		Other VOA	ND_1
		1,1,1-trichloroethane	29.6 (ND_1 in dup)
	12/03/85	B/N	ND_5
	12/05/85	Trichloroethylene	1.1 B
		Other VOA	ND_1
		Mercury	0.2
		Chloride	43 mg/l
DH-3	08/25/82	Chloroform	3 B
		Trichloroethylene	8 B
		Chlorobenzene	7 B
		Toluene	2 B
		Benzene	7 B
		Other VOA	ND_1
		1,4-dichlorobenzene	30 B
		Other B/N	ND_{10}

TABLE 2 (Continued)

SUMMARY OF MIOCENE SAMPLING RESULTS

Well Number	Sampling Date	Parameter	Concentration (μg/l, unless otherwise indicated)
		Mercury	$ND_{0.1}$
		Chloride	27 mg/l
	10/15/85	Mercury	$ND_{0.1}$
		Chloride	31 mg/l
		1,1,1-Trichloroethane	2.50
		1,1-Dichloroethane	4.10
		1,1-Dichloroethene	3.80
		Carbon tetrachloride	2.10
		Chloroform	14.20
		Trichloroethene	1.30
		Trichlorofluoromethane	10.10
	12/03/85	Bis(2-ethyl hexyl)phthalate	5.4
		Other B/N	ND_5
	12/05/85	Trichlorofluoromethane	2.1
		Other VOA	ND_1
		Mercury	0.2
		Chloride	22 mg/l
WW-3	02/04/82	Methylene chloride	12 B
		Benzene	1.2 B
		Toluene	5.3 B
		Chlorobenzene	0.1
		Mercury	0.5
WW-8	02/04/82	Benzene	0.7 B
		Toluene	4.7 B
		Chlorobenzene	20.4
		Other VOA	ND_{10}
		Methylene Chloride	243 B
		Mercury	0.2
	03/16/82	Benzene	11
		Toluene	4
		Tetrachloroethene	6
		Chlorobenzene	223
		Chloroform	8
		1.2-dichlorobenzene	20
	08/04/82	Benzene	ND/4 B[1]
		Toluene	ND/2 B[1]
		Trichloroethylene	ND/8 B[1]

TABLE 2 (Continued)

SUMMARY OF MIOCENE SAMPLING RESULTS

Well Number	Sampling Date	Parameter	Concentration ($\mu g/l$, unless otherwise indicated)
		Chloroform	ND/6 B[1]
		Chlorobenzene	13/35[1]
		Lead	59/NA[1]
		Manganese	21/NA[1]
		Acrylonitrite	<100/NA[1]
		Mercury	$ND_{0.2}/ND_{0.1}$[1]
		Chloride	NA/517[1]mg/l
	08/25/83	VOA	ND_{10}
		Mercury	$ND_{0.1}$
		Chloride	238 mg/l
	06/21/84	VOA	ND_{10}
		Chloride	80 mg/l
	05/09/84	1,2-dichlorobenzene	4
		VOA	ND_1
		B/N	ND_{20}
	12/03/85	B/N	ND_5
	12/05/85	Trichloroethylene	1.6
		Other VOA	ND_1
		B/N	ND_5
WW-9	12/03/85	B/N	ND_5
	12/05/85	VOA	ND_1
		Mercury	$ND_{0.1}$
		Chloride	80 mg/l
WW-10	12/05/85	Toluene	2.4
		Chlorobenzene	7.3
		1.2-dichlorobenzene	7.5
		1,4-dichlorobenzene	11.1
		Other VOA	ND_1
WW-11	12/03/85	Other B/N	ND_5
		Benzo(k)fluoranthene	5.4
	12/05/85	Methylene chloride	2.6
		Other VOA	ND_1
		Mercury	$ND_{0.1}$
		Chloride	153 mg/l

TABLE 2 (Continued)

SUMMARY OF MIOCENE SAMPLING RESULTS

Well Number	Sampling Date	Parameter	Concentration ($\mu g/l$, unless otherwise indicated)
WW-12	05/31/85	Mercury	$ND_{0.1}$
		Chloride	677 mg/l
	12/03/85	Di-N-butyl phthalate	6.0
		Other B/N	ND_5
	12/05/85	Methylene chloride	3.4
		Trichloroethylene	9.7
		Chlorobenzene	58
		1,2-dichlorobenzene	76.8
		1,3-dichlorobenzene	5.8
		1,4-dichlorobenzene	42.5
		Other VOA	ND_1
		Mercury	0.2
		Chloride	379 mg/l

NOTES:

B = Parameter found in the blank.
B/N = Base neutrals.
NA = Not analyzed.
ND = Not detected above detection limits. Detection limit (in ιg/l) indicated as a subscript.
VOA = Volatile Organic Analysis.
[1] = 08/04/82 split with EPA. Results are EPA/Olin.

TABLE 3

CHEMICAL ANALYSIS OF WEAK BRINE POND[1] COMPOSITE SLUDGE SAMPLES

Prior to Solidification

Analysis	**Units**	**Range**	**Average**
pH		11.4-12.2	12.0
Solids	Percent	25-45	31
Density	g/ml	1.1-1.4	1.2
Total alkalinity	µg/g	78,000/111,000	91,900
EP Toxicity:			
As	mg/l	ND-0.002	0.0005
Ba	mg/l	ND-0.1	ND
Cd	mg/l	ND-0.02	0.01
Cr	mg/l	---	ND
Pb	mg/l	---	ND
Hg	mg/l	0.35-1.38	0.85
Se	mg/l	---	ND
Ag	mg/l	---	ND
Metal Concentrations:			
As	mg/kg	0.29-0.83	0.46
Ba	mg/kg	ND-32	4.0
Cd	mg/kg	0.46-1.0	0.75
Cr	mg/kg	ND-6	1.1
Pb	mg/kg	ND-40	17
Hg	mg/kg	111-498	272
Ni	mg/kg	ND-11	7.1
Se	mg/kg	ND-0.07	0.009
Ag	mg/kg	---	ND
TOC	mg/kg	466-653	558

TABLE 3 (Continued)

CHEMICAL ANALYSIS OF WEAK BRINE POND COMPOSITE SLUDGE SAMPLES

Solidified Sludge:

Analysis	Units	Value
Free Liquids	Percent	0
EP Toxicity		
As	μg/l	ND
Ba	μg/l	ND
Cd	μg/l	ND
Cr	μg/l	250
Pb	μg/l	200
Hg	μg/l	110
Se	μg/l	ND
Ag	μg/l	ND

NOTES:

1 = Results are from Waste Stabilization Study
ND = Non-detectable

TABLE 4

SUMMARY OF CONFIRMATION SAMPLE RESULTS
HEXACHLOROBENZENE SPOIL AREA

Sample No.	ALRS[2] Results (mg/kg HCB)	Remarks
A1	<0.1	EPA provided blind reference sample.
A2	25.6	Blind duplicate of C2.
A3	0.6	
A3ES	208[1]	Sample collected where 3-centerline intersects east slope.
A4	0.5	
A4ES	118	Sample collected where 4-centerline intersects east slope.
A5	62	
A6	0.5	Blind duplicate of A4-2.
B-1	1.7	
B-2	7.2	
B-3	9.3	
B-4	68	
C-1	6.6	
C-2	1.3	
C-3	88.9	
C-4	1.4	
C4SS	172	Sample collected where C-centerline intersects south face of northern extent of excavation.
D1	1.0	
D2	0.3	
D3	29.9	

TABLE 4 (Continued)

SUMMARY OF CONFIRMATION SAMPLE RESULTS
HEXACHLOROBENZENE SPOIL AREA

Sample No.	ALRS[2] Results (mg/kg HCB)	Remarks
D4	0.8	
D5	4.6	
E2	0.6	
E3	2.8	
E4	0.8	
E5	8.7	
E6	<0.1	
E6SS	8.8	Sample collected where E-centerline intersects south face of northern extent of excavation.
F3	<0.1	
F4	0.2	
F5	54.0	
F6	3.5	
F/G-6	<1.0	Sample collected where 6-centerline intersects edge of excavation between F-centerline and G-centerline.
G-5	1.0	
Rinsate Blank	<0.1 mg/l	

NOTES:

1 Although above the 200 mg/kg, EPA determined that the sample result was within acceptable variance of the designated criteria and no further excavation was required.

2 ALRS - American Laboratory and Research Services, Hattiesburg, Mississippi.

NA Not analyzed.

TABLE 5

CONTAMINANT ANALYSIS OLIN BASIN
DECEMBER 1987

Location	Mercury/Rep	Extract/Rep	1,2-DCB/Rep	1,4-DCB/Rep	PCNB/Rep	HCB/Rep
			Sediment - All Values mg/kg (ppm)			
A	0.4/<0.3	<0.2/<0.2	0.35/<0.66	0.33/<0.66	5.72/11.7	31.5/35.3
B	2.1/2.65[1]	<0.2/<0.2[1]	<0.66/<0.66[1]	<0.66/<0.66[1]	<0.66/<0.66[1]	2.4/2.1[1]
C	60.5/9.0[1]	<0.2/<0.2[1]	<0.66/<0.66[1]	<0.66/<0.66[1]	<0.66/<0.66[1]	21.0/1.9[1]
D	1.55/1.7[1]	<0.2/<0.2[1]	<0.66/<0.66[1]	<0.66/<.066[1]	<0.66/14.5[1]	11.3/41.7[1]
E	4.5/9.5	<0.2/<0.2	<0.66/<0.66	<0.66/<0.66	<0.66/<0.66	<0.66/<0.66
F	25.5/8.0	<0.2/<0.2	<0.66/<0.66	<0.66/<0.66	<0.66/<0.66	<0.66/<0.66
GN	2.55/NA	0.4/NA	<0.66/<0.66	<0.66/NA	<0.66/NA	<0.66/NA
GS	2.6/NA	<0.2/NA	<0.66/NA	<0.66/NA	<0.66/NA	<0.66/NA
H	3.95/NA	<0.2/NA	<0.66/NA	<0.66/NA	<0.66/NA	<0.66/NA
I	11.0/4.0[1]	<0.2/<0.2[1]	<0.66/<0.33[2]	<0.66/<0.33[2]	4.9/<0.33[2]	114/69.6[2]
			Surface Water - All Values μg/l (ppb)			
A	1.0/1.0	NP	<10.0/<10.0	<10.0/<10.0	<10.0/<10.0	<10.0/<10.0
B	2.0/NA	NP	<10.0/NA	<10.0/NA	<10.0/NA	<10.0/NA
C	0.7/NA	NP	<10.0/NA	<10.0/NA	<10.0/NA	<10.0/NA
D	0.7/NA	NP	<10.0/NA	<10.0/NA	<10.0/NA	<10.0/NA
E	0.6/<0.2	NP	<10.0/<10.0	<10.0/<10.0	<10.0/<10.0	<10.0/<10.0
F	0.7/0.6	NP	<10.0/<10.0	<10.0/<10.0	<10.0/<10.0	<10.0/<10.0
GN	0.4/NA	NP	<10.0/NA	<10.0/NA	<10.0/NA	<10.0/NA
GS	0.5/NA	NP	<10.0/NA	<10.0/NA	<10.0/NA	<10.0/NA

NOTES:

1,2-DCB:	1,2-Dichlorobenzene
1,4-DCB:	1,4-Dichlorobenzene
PCNB:	Pentachloronitrobenzene
HCB:	Hexachlorobenzene
Rep:	Replicate
NA:	Not analyzed
NP:	Not applicable
1	Extracted and analyzed after 30-day holding time.
2	Sample re-extracted and analyzed after 30-day holding time.

3 4 00195

TABLE 6

WELL CONSTRUCTION DETAILS

Well Number	Year Installed	Total Depth (feet)	Casing Diam. (in), Depth (ft) Screen Diam. (in), Depth (ft)	Zone Monitored	Well Type
BR-7	1980	43	2, 0-33 2 (SCN), 33-43	Alluvial	Monitoring
BR-7D	1986	78	6, NA 4 (SCN), 55-75	Alluvial	Monitoring
BR-8	1980	51.5	2, 0-30 2 (SCN), 30-50	Alluvial	Monitoring
BR-8D	1986	91	6, NA 4(SCN), 79-90	Alluvial	Monitoring
BR-10	1981	48	2, 0-28 2 (SCN), 28-48	Alluvial	Monitoring
E-1	1982	105	2, 0-75 2 (SCN), 75-85	Alluvial	Monitoring
E-2	1982	50	2, 0-45 2 (SCN), 45-50	Alluvial	Monitoring
E-4	1982	50	2, 0-45 2 (SCN), 45-50	Alluvial	Monitoring
E-5	1982	80	6, 0-60 2, 0-65.2 2 (SCN), 65.2-75.2	Alluvial Alluvial	Monitoring Monitoring
E-6	1982	50	2, 0-42.8 2 (SCN), 42.8-47.8	Alluvial	Monitoring
LP-3	1980	40	2, 0-30 2 (SCN), 30-40	Alluvial	Monitoring
MP-8	1982	95	6, 0-50 2, 0-78.8 2 (SCN), 78.8-83.8	Alluvial	Monitoring
MP-13	1982	100	6, 0-70 2, 0-85 2 (SCN), 85-95	Alluvial	Monitoring

TABLE 6 (Continued)

WELL CONSTRUCTION DETAILS

Well Number	Year Installed	Total Depth (feet)	Casing Diam. (in), Depth (ft) Screen Diam. (in), Depth (ft)	Zone Monitored	Well Type
MP-14	1988	90	2, 0-76 2 (SCN), 76-86	Alluvial	Monitoring
MP-15	1988	90	2, 0-74 2 (SCN), 74-84	Alluvial	Monitoring
PE-1	1981	38	2, 0-28 2 (SCN), 28-38	Alluvial	Monitoring
PE-3D	1983	73	4, 0-48 4 (SCN), 48-73	Alluvial	Monitoring
PH-2	1980	38	2, 0-28 2 (SCN), 28-38	Alluvial	Monitoring
PH-2D	1983	80	4, 0-55 4 (SCN), 55-80	Alluvial	Monitoring
PH-3	1980	27	2, 0-17 2 (SCN), 17-27	Alluvial	Monitoring
PH-3D	1983	74	4, 0-49 4 (SCN), 49-74	Alluvial	Monitoring
PH-7	1980	43	2, 0-22 2 (SCN), 22-42	Alluvial	Monitoring
PH-7D	1983	75	4, 0-50 4 (SCN), 50-75	Alluvial	Monitoring
PH-8	1980	40	2, 0-20 2 (SCN), 20-40	Alluvial	Monitoring
PL-4D	1983	92	4, 0-77 4 (SCN), 77-92	Alluvial	Monitoring
PL-4S	1983	60	4, 0-45 4 (SCN), 45-60	Alluvial	Monitoring
PL-5D	1983	101	4, 0-84 4 (SCN), 84-99	Alluvial	Monitoring

TABLE 6 (Continued)

3 4 00197

WELL CONSTRUCTION DETAILS

Well Number	Year Installed	Total Depth (feet)	Casing Diam. (in), Depth (ft) Screen Diam. (in), Depth (ft)	Zone Monitored	Well Type
PL-8D	1985	83	4, 0-63 4 (SCN), 63-83	Alluvial	Monitoring
PL-8S	1985	47	4, 0-27 4 (SCN), 27-47	Alluvial	Monitoring
PL-9D	1985	77	4, 0-57 4 (SCN), 57-77	Alluvial	Monitoring
PL-9S	1985	40	4, 0-20 4 (SCN), 20-40	Alluvial	Monitoring
PL-10S	1985	38	4, 0-18 4 (SCN), 18-38	Alluvial	Monitoring
SL-2	1980	18	2,0-8 2 (SCN), 8-18	Alluvial	Monitoring
SL-3	1980	48	2, 0-38 2 (SCN), 38-48	Alluvial	Monitoring
SL-4	1980	33	2, 0-23 2 (SCN), 23-33	Alluvial	Monitoring
WE-3	1980	61.5	2, 0-37 2 (SCN), 37-57	Alluvial	Monitoring
WP-6	1982	82	2, 0-57.5 2 (SCN), 57.5-67.5	Alluvial	Monitoring
WP-9A	1982	50	2, 0-43.5 2 (SCN), 43.5-48.5	Alluvial	Monitoring
CA-1	1987	103	10, 0-40 10 (SCN), 40-100	Alluvial	Recovery
CA-2	1987	83	10, 0-20 10 (SCN), 20-80	Alluvial	Recovery
CA-3	1987	100	10, 0-40 10 (SCN), 40-100	Alluvial	Recovery

TABLE 6 (Continued)

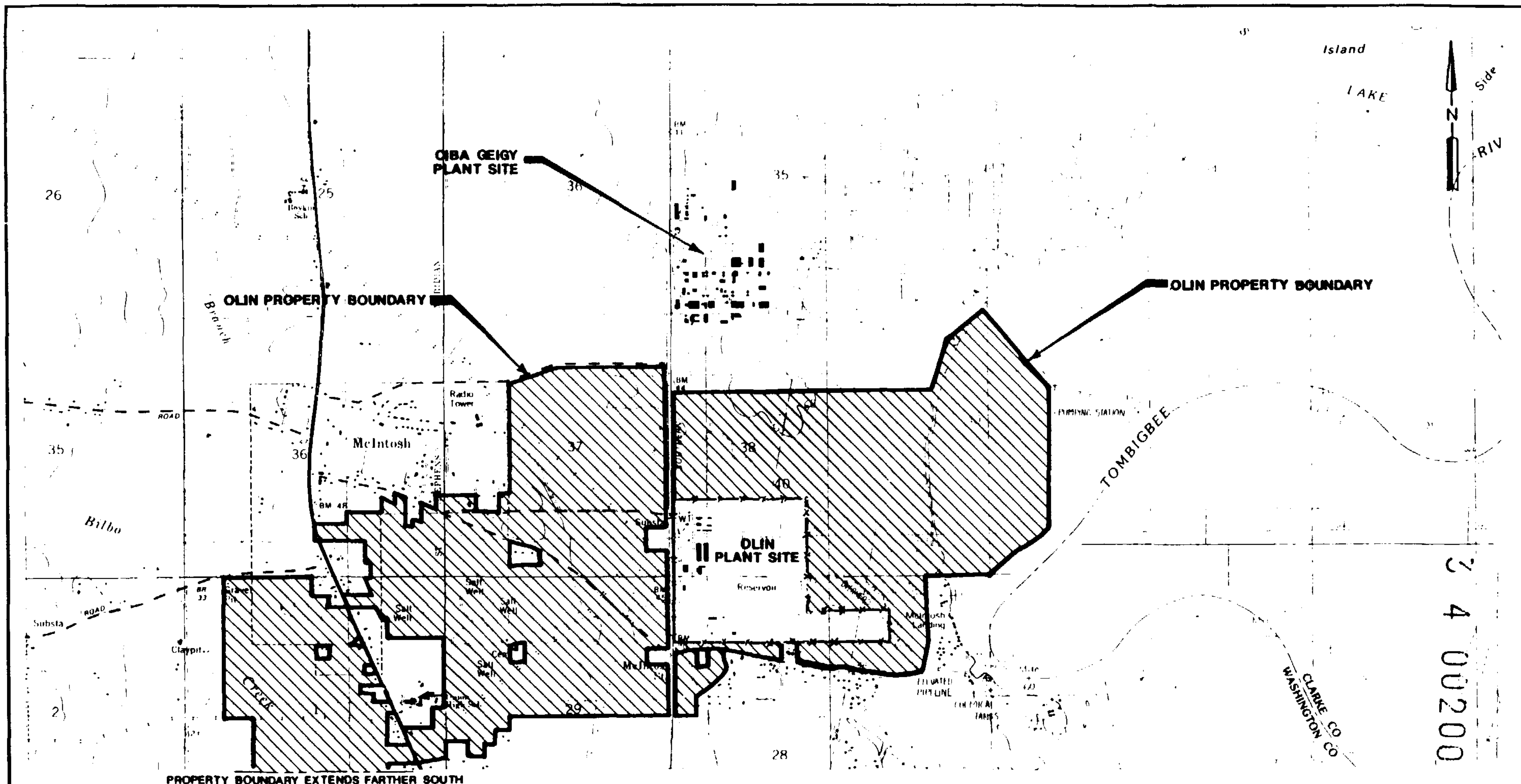
WELL CONSTRUCTION DETAILS

Well Number	Year Installed	Total Depth (feet)	Casing Diam. (in), Depth (ft) Screen Diam. (in), Depth (ft)	Zone Monitored	Well Type
CA-4	1987	98	10, 0-40 10 (SCN), 40-100	Alluvial	Recovery
CA-5	1987	88	10, 0-30 10 (SCN), 30-90	Alluvial	Recovery
DH-1	1982	240	6, 0-100 2, 0-228 2 (SCN), 228-238	Miocene	Monitoring
DH-3	1982	196	6, 0-100 2, 0-186 2 (SCN), 186-196	Miocene	Monitoring
WW-8	1976	272.5	20, 0-192.75 12, 160-210 12 (SCN), 210-270	Miocene	Production

NOTES:

SCN = Screen
NA = Information Not Available

FIGURES



LEGEND

—x— OLIN PLANT SITE FENCE LINE

▧ OLIN PROPERTY BEYOND PLANT SITE

0 (FEET) 2000
SCALE

RI/FS
McINTOSH PLANT SITE

Woodward-Clyde Consultants
Consulting Engineers, Geologists
and Environmental Scientists
Baton Rouge, Louisiana

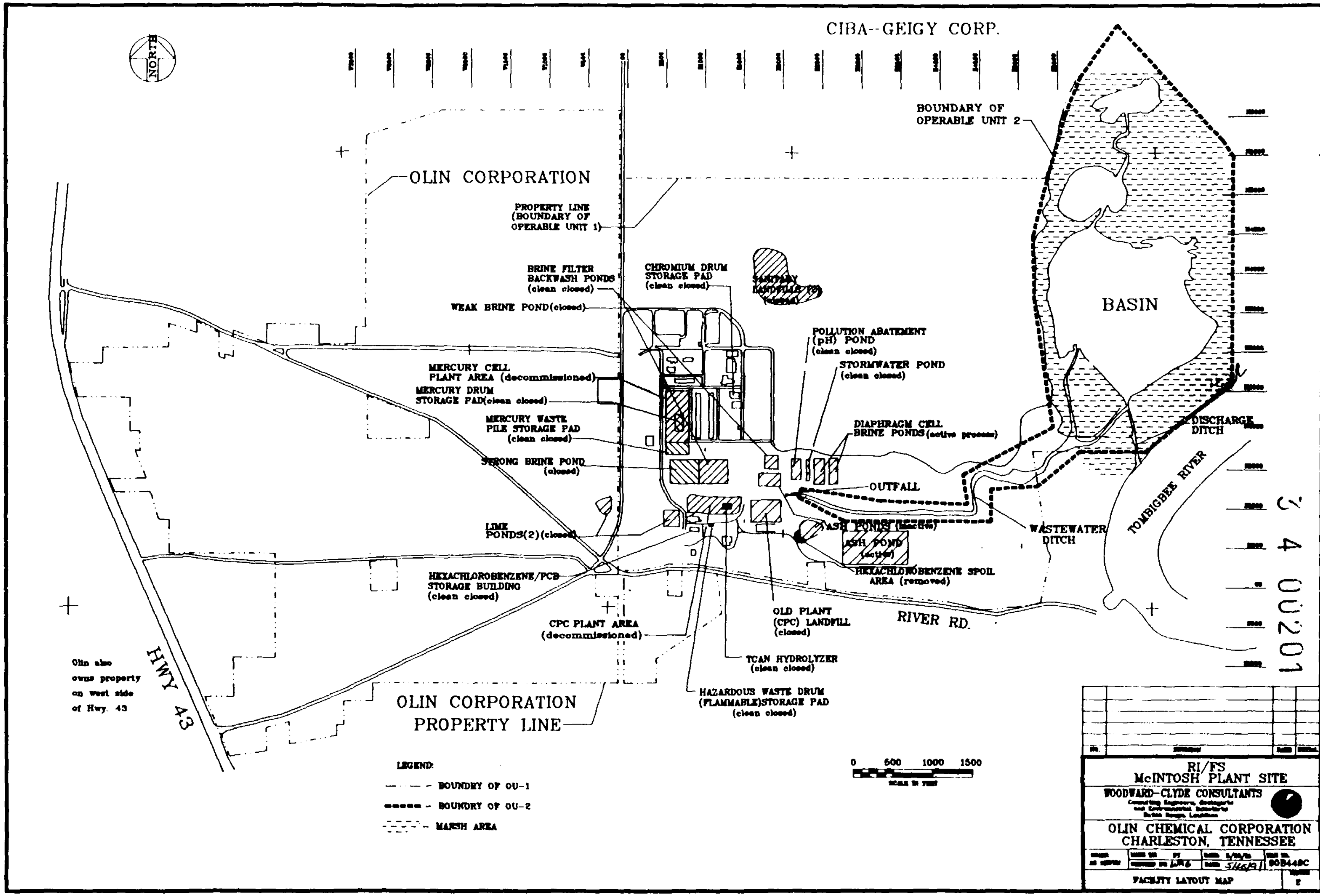
OLIN CHEMICAL CORPORATION
CHARLESTON, TENNESSEE

SCALE: AS SHOWN	MADE BY: SJL	DATE: 12/90	FILE NO. 90B448C
	CHECKED BY: WAB	DATE: 12/90	

SITE LOCATION MAP

FIGURE 1

RE: U.S.G.S. 7.5 MINUTE SERIES QUADRANGLE MAP, McINTOSH, ALABAMA, 1984 AND GINHOUSE ISLAND, ALABAMA, 1984.


CIBA--GEIGY CORP.
NORTH
BOUNDARY OF OPERABLE UNIT 2
OLIN CORPORATION
PROPERTY LINE (BOUNDARY OF OPERABLE UNIT 1)
BASIN
BRINE FILTER BACKWASH PONDS (clean closed)
CHROMIUM DRUM STORAGE PAD (clean closed)
SANITARY LANDFILL
WEAK BRINE POND (closed)
POLLUTION ABATEMENT (pH) POND (clean closed)
STORMWATER POND (clean closed)
MERCURY CELL PLANT AREA (decommissioned)
MERCURY DRUM STORAGE PAD (clean closed)
MERCURY WASTE PILE STORAGE PAD (clean closed)
DIAPHRAGM CELL BRINE PONDS (active process)
DISCHARGE DITCH
STRONG BRINE POND (closed)
OUTFALL
TOMBIGBEE RIVER
LIME PONDS(2) (closed)
ASH PONDS (inactive)
ASH POND (active)
WASTEWATER DITCH
HEXACHLOROBENZENE SPOIL AREA (removed)
HEXACHLOROBENZENE/PCB STORAGE BUILDING (clean closed)
RIVER RD.
OLD PLANT (CPC) LANDFILL (closed)
CPC PLANT AREA (decommissioned)
TCAN HYDROLYZER (clean closed)
Olin also owns property on west side of Hwy. 43
HWY 43
HAZARDOUS WASTE DRUM (FLAMMABLE) STORAGE PAD (clean closed)
OLIN CORPORATION PROPERTY LINE
LEGEND:
BOUNDRY OF OU-1
BOUNDRY OF OU-2
MARSH AREA
0 500 1000 1500
SCALE IN FEET
RI/FS
McINTOSH PLANT SITE
WOODWARD-CLYDE CONSULTANTS
OLIN CHEMICAL CORPORATION
CHARLESTON, TENNESSEE
90B448C
FACILITY LAYOUT MAP
2
34 00201

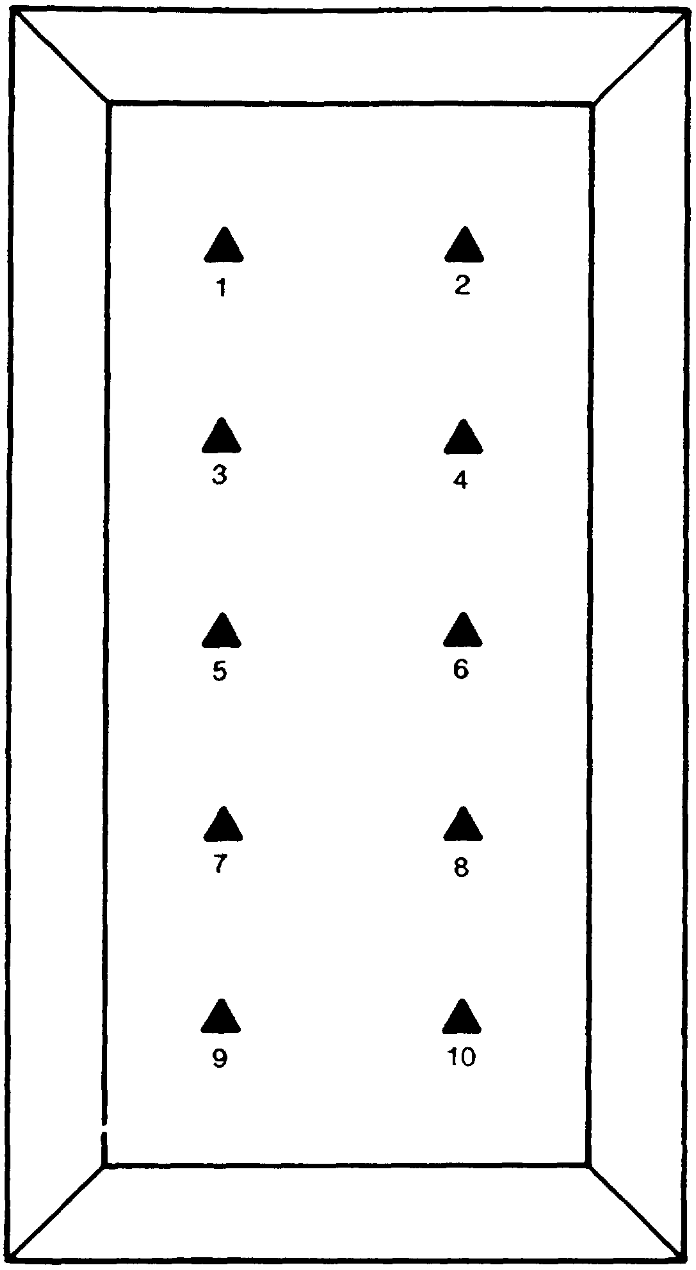
OVERSIZED

DOCUMENT

OVERSIZED

DOCUMENT

3 4 00204



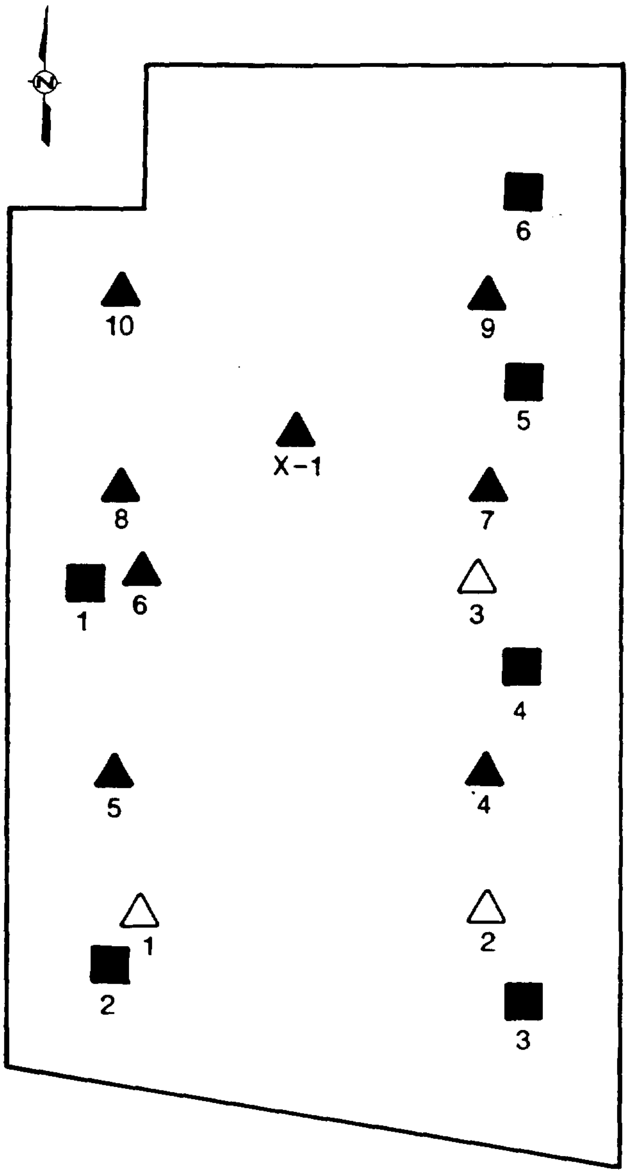
SAMPLE RESULTS

SAMPLE No.	Hg[1] (ug/l)
1	1.7
2	0.3
3	0.2
4	0.1
5	0.1
6	0.1
7	0.2
8	0.2
9	0.2
10	0.2

NOTE: #1 - ANALYSIS BY EP TOXICITY LEACHATE PROCEDURE

RI/FS McINTOSH PLANT SITE OLIN CHEMICAL CORPORATION CHARLESTON, TENNESSEE	Woodward-Clyde Consultants Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana		STORMWATER POND CLOSURE SAMPLE RESULTS	FILE NO. 90B4490
	SCALE: NTS	DRAWN BY: GT CHKD. BY:	DATE: 5/91 DATE:	FIG. NO. 4

3 4 00205



SAMPLE RESULTS

SAMPLE No.	pH
1	11.4
2	11.4
3	11.5
4	11.5
5	11.4
6	11.5

SAMPLE No.	Hg[1] (ug/l)
X-1	0.08
4	0.8
5	0.1
6	0.1
7	4.1
8	0.2
9	1.0
10	1.7

■ APPROXIMATE pH SAMPLE LOCATION

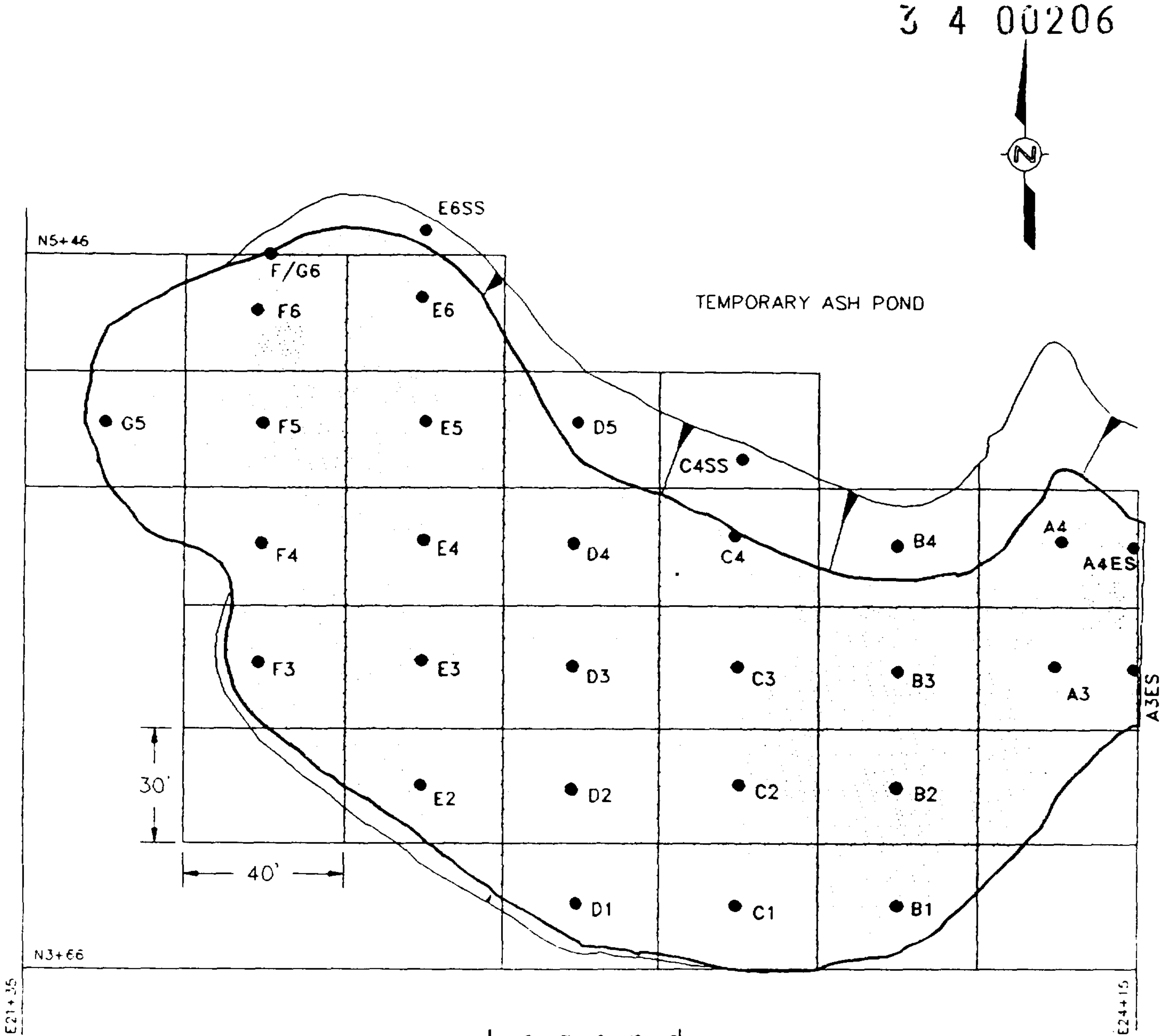
▲ APPROXIMATE Hg SAMPLE LOCATION

△ APPROXIMATE Hg SAMPLE LOCATION, NO DATA AVAILABLE

NOTE: #1 = ANALYSIS BY EP TOXICITY LEACHATE PROCEDURE

RI/FS McINTOSH PLANT SITE OLIN CHEMICAL CORPORATION CHARLESTON, TENNESSEE	Woodward-Clyde Consultants Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana SCALE: NTS · DRAWN BY: GT · DATE: 5/91 CHKD. BY: · DATE:	pH POND CLOSURE SAMPLE RESULTS	FILE NO. 90B449C FIG. NO. 5

3 4 00206



Legend

● SAMPLE LOCATION

☐ EXCAVATION AREA

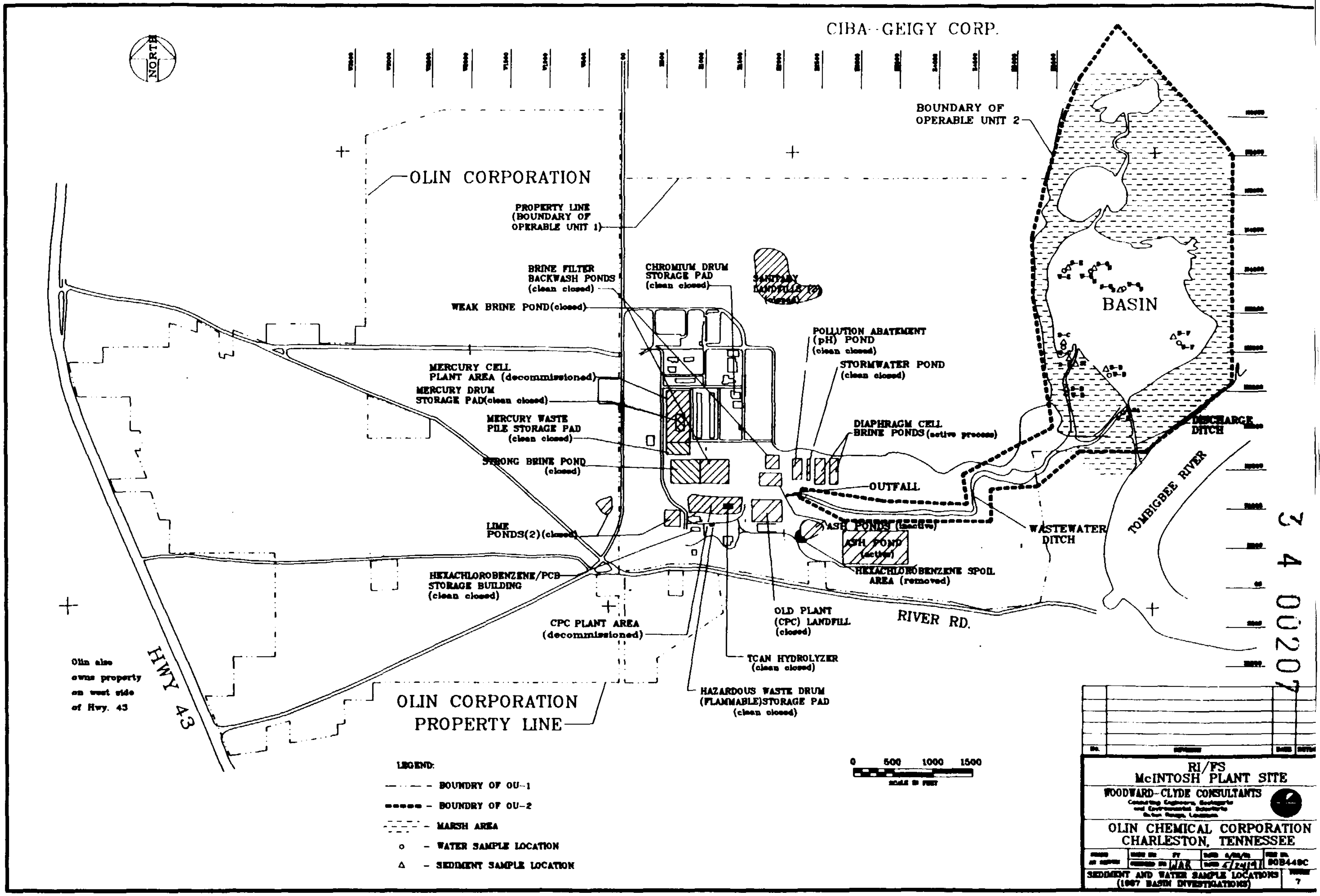
RE: FINISH EXCAVATION PLAN OF HEXACHLOROBENZENE CONTAMINATED SOIL AREA; OLIN, NOVEMBER 1990, DRAWING NO. D-5917-70-0-12, REV. 0.

SCALE

0 40 80 FEET

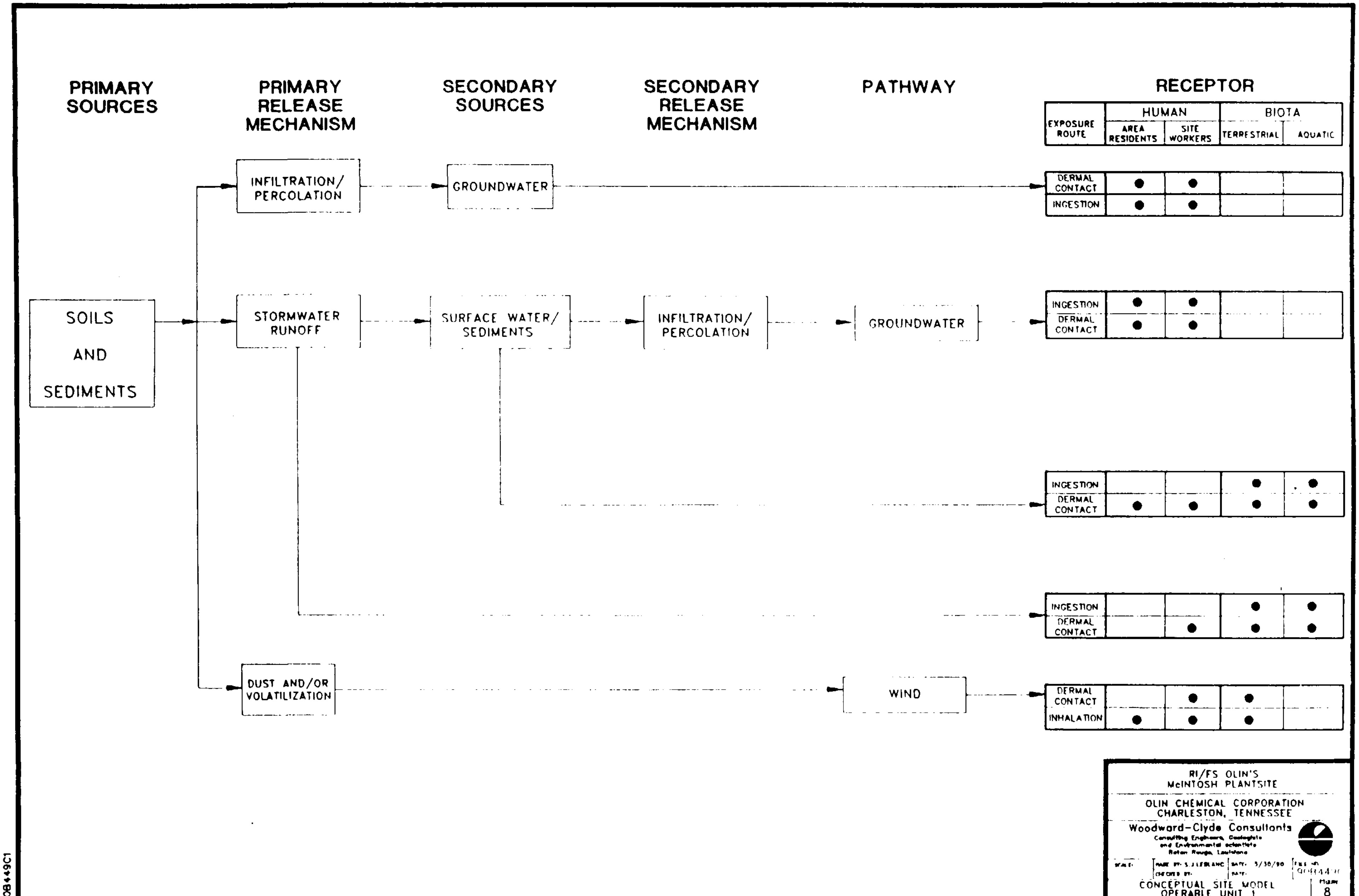
RI/FS McINTOSH PLANT SITE OLIN CHEMICAL CORPORATION CHARLESTON, TENNESSEE	Woodward-Clyde Consultants Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana SCALE: AS SHOWN	DRAWN BY: S. LEBLANC	DATE: 5/91	CHKD. BY:	DATE:	HEXACHLOROBENZENE SPOIL AREA CONFIRMATION SAMPLE GRID	FILE NO. 90B850C	FIG. NO. 6

08



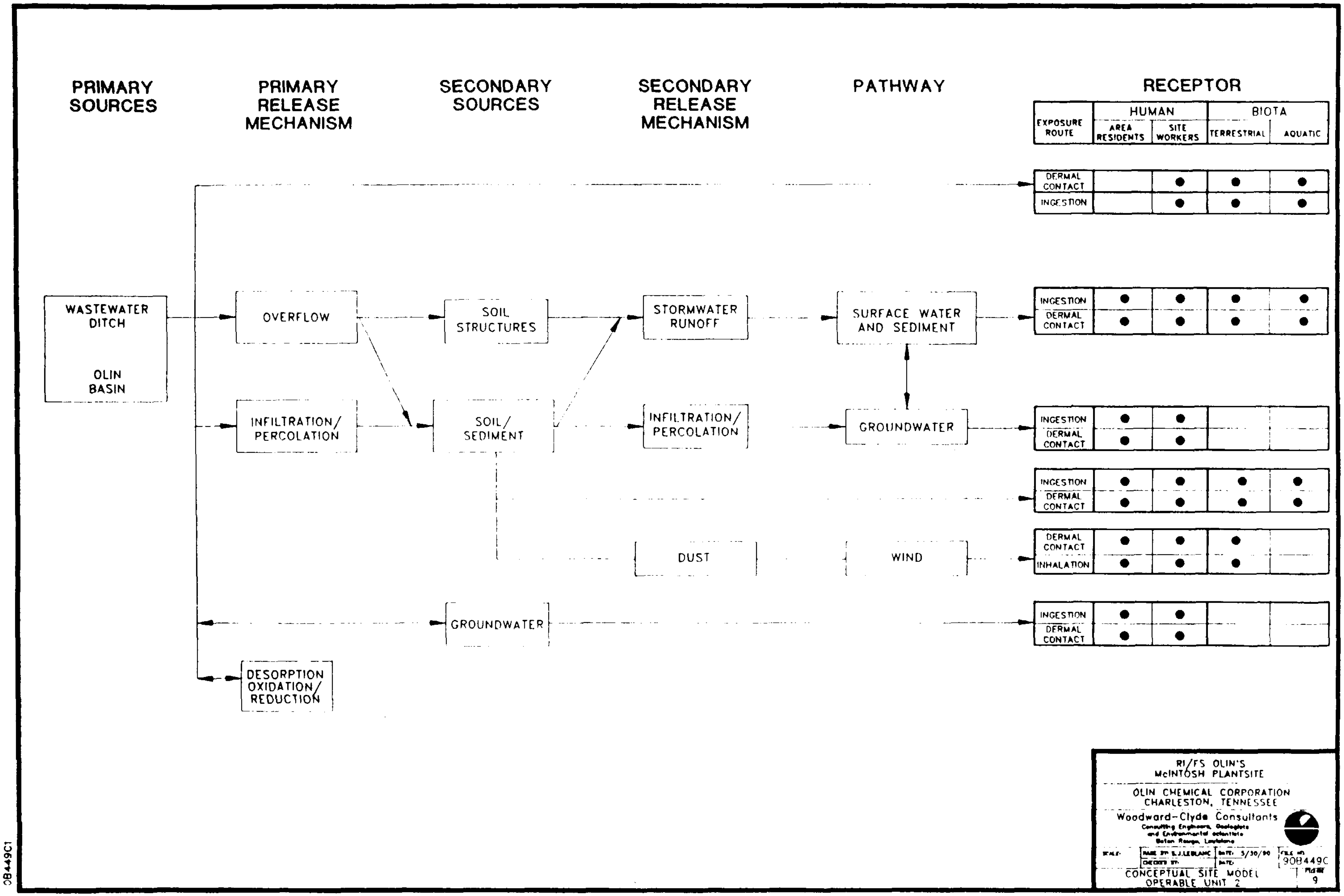
NORTH
CIBA-GEIGY CORP.
OLIN CORPORATION
BOUNDARY OF OPERABLE UNIT 2
PROPERTY LINE (BOUNDARY OF OPERABLE UNIT 1)
BRINE FILTER BACKWASH PONDS (clean closed)
CHROMIUM DRUM STORAGE PAD (clean closed)
WEAK BRINE POND(closed)
BASIN
POLLUTION ABATEMENT (pH) POND (clean closed)
STORMWATER POND (clean closed)
MERCURY CELL PLANT AREA (decommissioned)
MERCURY DRUM STORAGE PAD(clean closed)
MERCURY WASTE PILE STORAGE PAD (clean closed)
DIAPHRAGM CELL BRINE PONDS (active process)
DISCHARGE DITCH
STRONG BRINE POND (closed)
OUTFALL
TOMBIGBEE RIVER
LIME PONDS(2)(closed)
WASTEWATER DITCH
HEXACHLOROBENZENE SPOIL AREA (removed)
HEXACHLOROBENZENE/PCB STORAGE BUILDING (clean closed)
OLD PLANT (CPC) LANDFILL (closed)
RIVER RD.
CPC PLANT AREA (decommissioned)
TCAN HYDROLYZER (clean closed)
Olin also owns property on west side of Hwy. 43
HWY 43
HAZARDOUS WASTE DRUM (FLAMMABLE)STORAGE PAD (clean closed)
OLIN CORPORATION PROPERTY LINE
LEGEND:
BOUNDRY OF OU-1
BOUNDRY OF OU-2
MARSH AREA
WATER SAMPLE LOCATION
SEDIMENT SAMPLE LOCATION
0 500 1000 1500
SCALE IN FEET
RI/FS
McINTOSH PLANT SITE
WOODWARD-CLYDE CONSULTANTS
OLIN CHEMICAL CORPORATION
CHARLESTON, TENNESSEE
SEDIMENT AND WATER SAMPLE LOCATIONS (1987 BASIN INVESTIGATIONS)
7

3 4 00207



08449C1

3 4 00208



0B449C1

3 4 00209

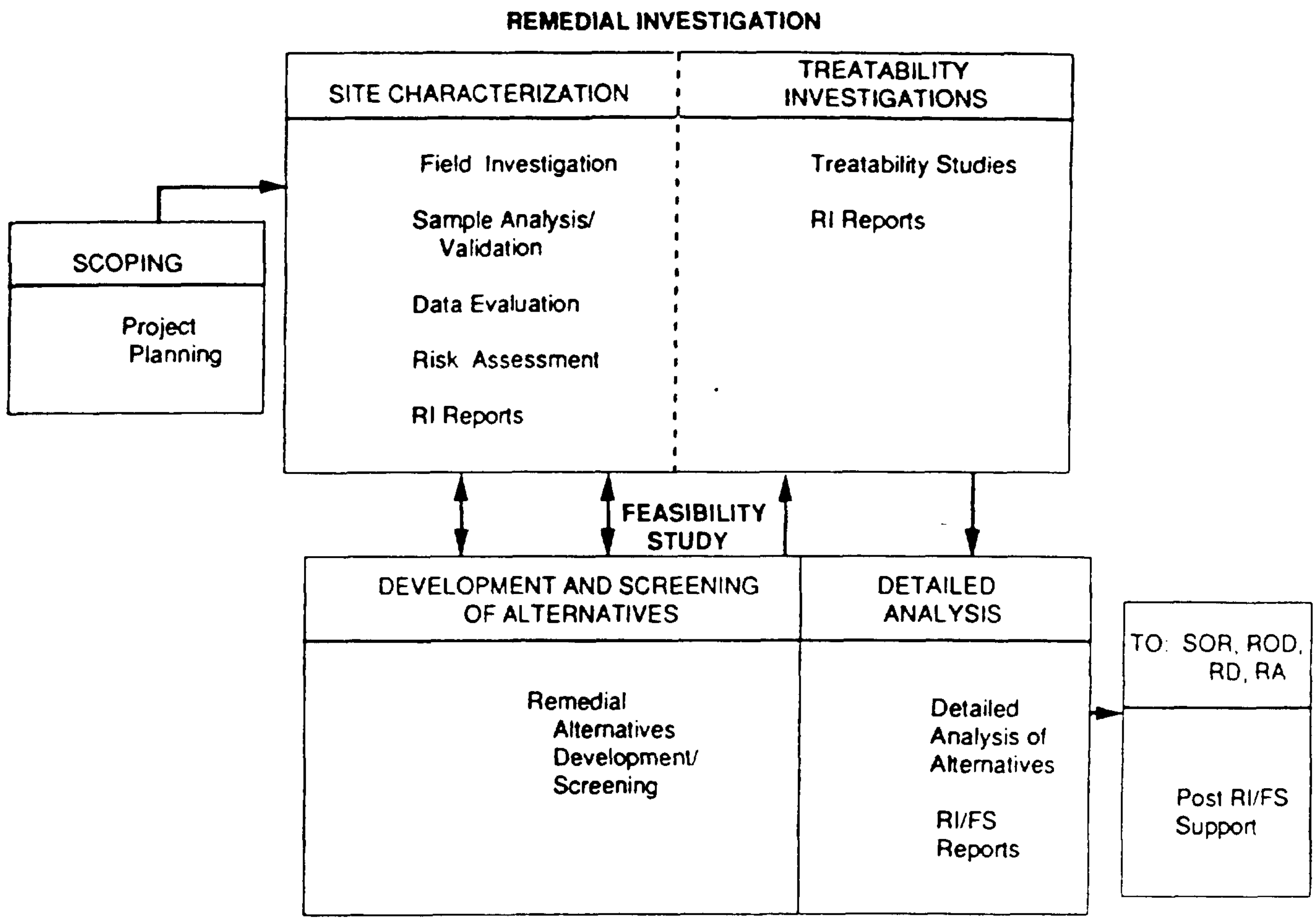
OVERSIZED

DOCUMENT

OVERSIZED

DOCUMENT

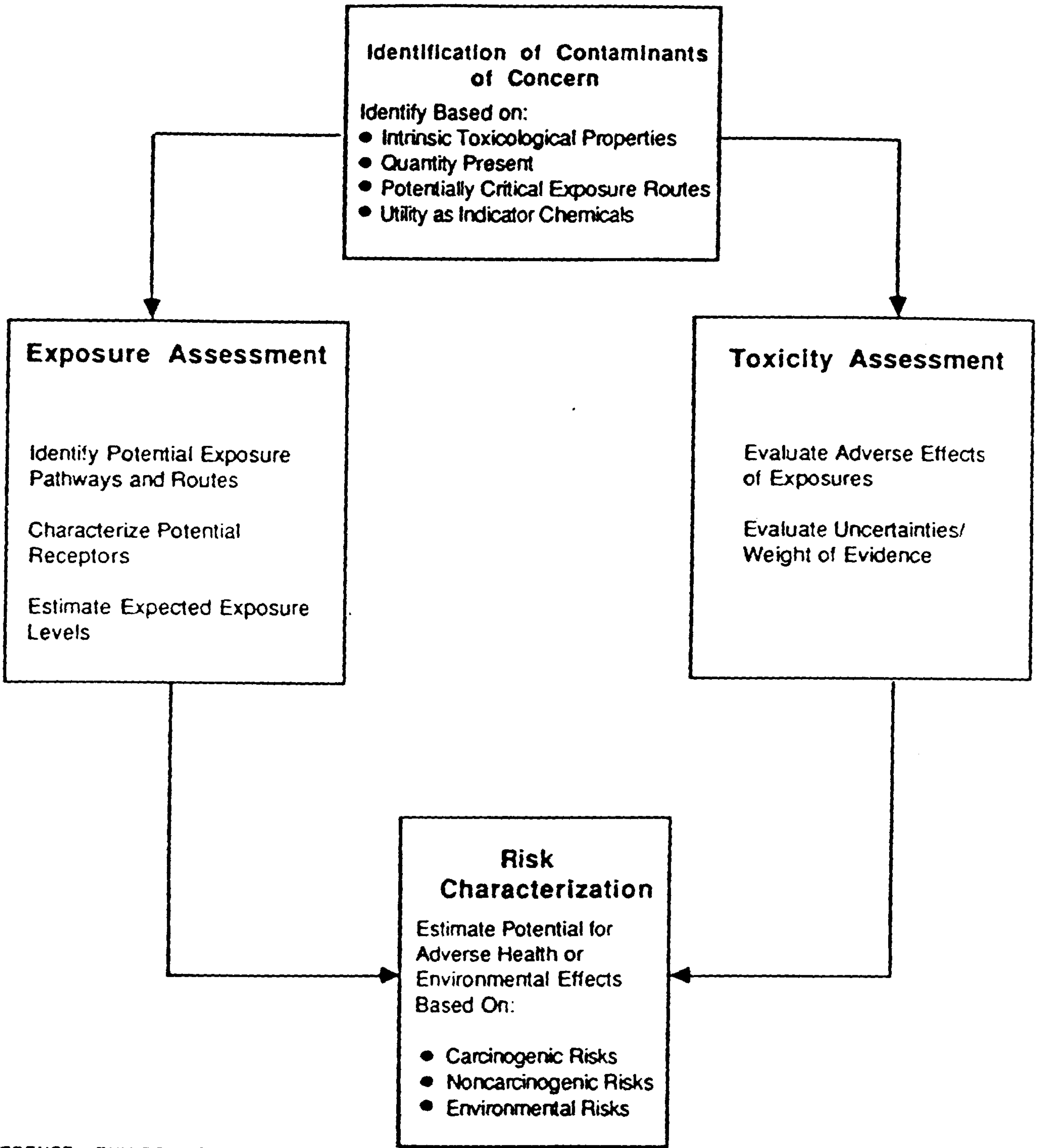
3 4 00212



REFERENCE: ENVIRONMENTAL PROTECTION AGENCY (EPA)

Office of Solid Waste and Emergency Response (OSWER), Directive 9355-3-01, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Fund, October, 1988.

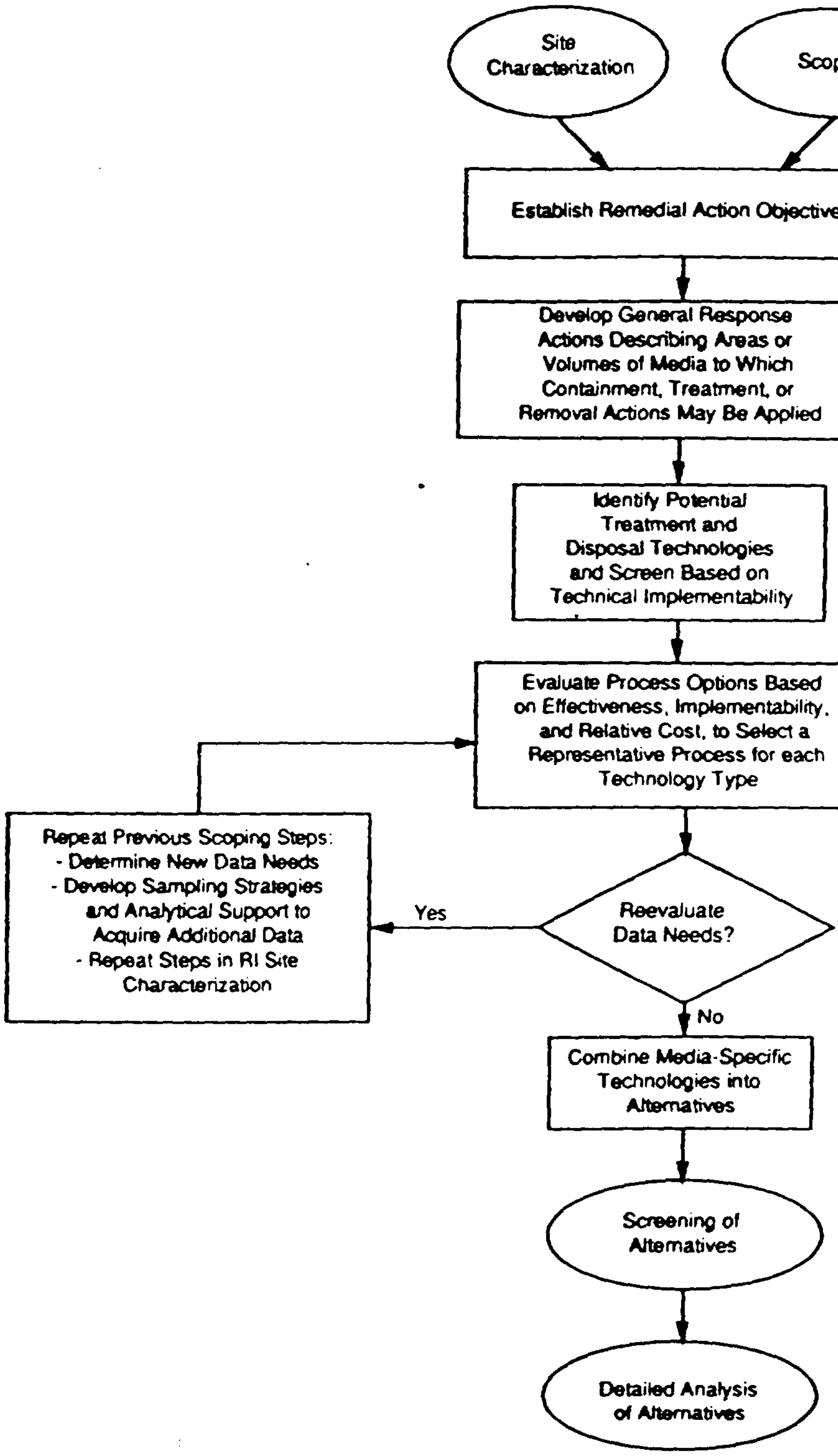
RI/FS McINTOSH PLANT SITE OLIN CHEMICAL CORPORATION CHARLESTON, TENNESSEE	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana SCALE: / DRAWN BY: SB / DATE: 12-90 CHKD. BY: WAB / DATE: 5/23/91	OVERALL RI/FS APPROACH MODEL	FILE NO 90B449C FIG NO 11



REFERENCE: ENVIRONMENTAL PROTECTION AGENCY (EPA)

Office of Solid Waste and Emergency Response (OSWER), Directive 9355-3-01, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Fund, October, 1988.

RI/FS McINTOSH PLANT SITE OLIN CHEMICAL CORPORATION CHARLESTON, TENNESSEE	Woodward-Clyde Consultants Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana	RISK ASSESSMENT MODEL	FILE NO. 908449C FIG NO. 12
	SCALE: / DRAWN BY: SB / DATE: 12-90 CHKD. BY: JAB / DATE: 5/23/91		

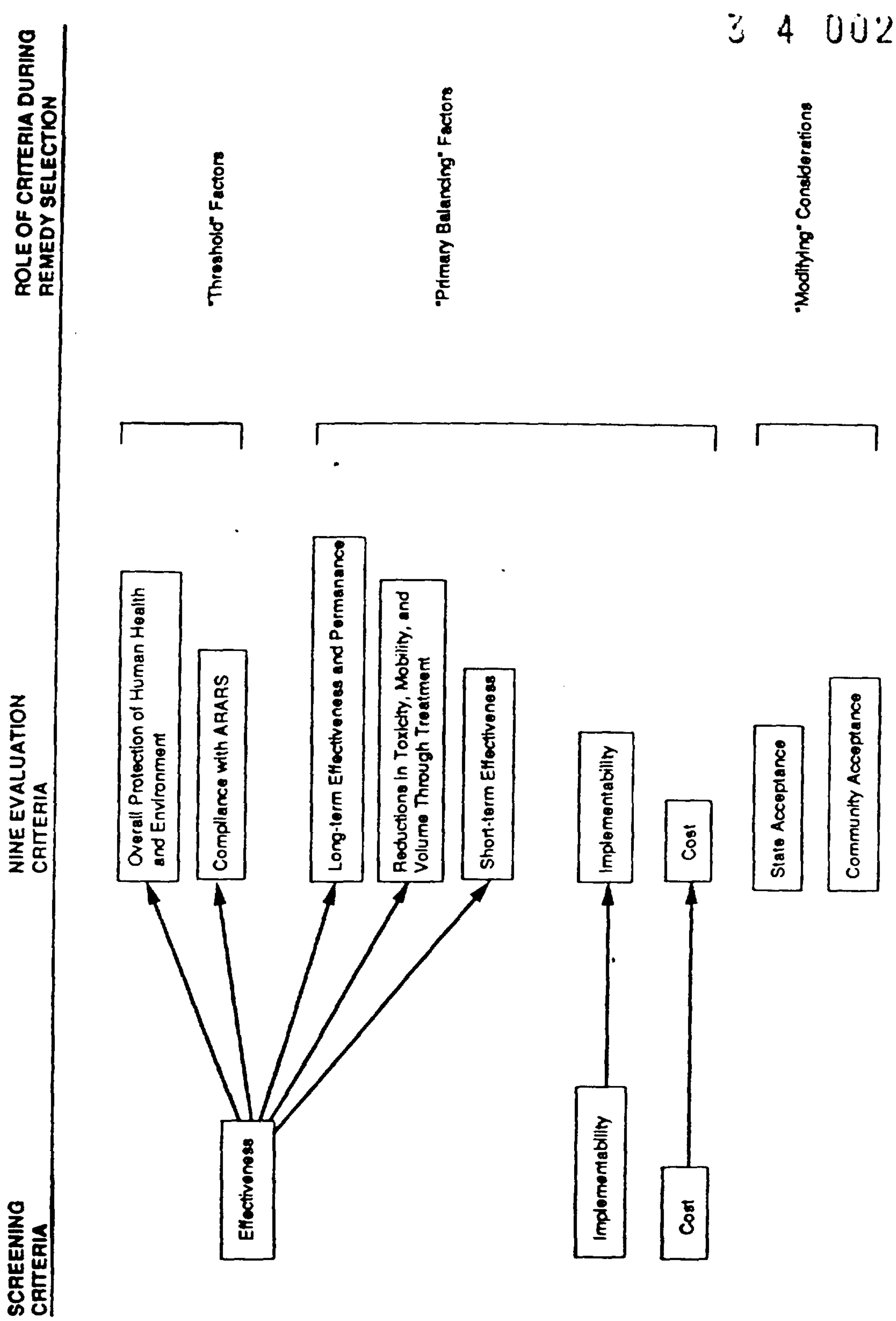


REFERENCE: ENVIRONMENTAL PROTECTION AGENCY (EPA)

Office of Solid Waste and Emergency Response (OSWER), Directive 9355-3-01, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Fund, October, 1988.

RI/FS McINTOSH PLANT SITE OLIN CHEMICAL CORPORATION CHARLESTON, TENNESSEE	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana SCALE: / DRAWN BY: SB / DATE: 12-90 CHKD. BY: [illegible] / DATE: 5/23/91	ALTERNATIVE DEVELOPMENT PROCESS	FILE NO. 90B449C FIG. NO. 13

3 4 00215



REFERENCE: ENVIRONMENTAL PROTECTION AGENCY (EPA)

Office of Solid Waste and Emergency Response (OSWER), Directive 9355-3-01, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Fund, October, 1988.

RI/FS
McINTOSH PLANT SITE

OLIN CHEMICAL CORPORATION
CHARLESTON, TENNESSEE

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists
Baton Rouge, Louisiana

SCALE | DRAWN BY: SB | DATE 12-90
CHKD. BY: JAK | DATE: 5/23/91

SCREENING AND EVALUATION PROCESS

FILE NO. 90B449C

FIG NO 14

3 4 00216

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- How Alternative Provides Human Health and Environmental Protection

COMPLIANCE WITH ARARs

- Compliance With Chemical-Specific ARARs
- Compliance With Action-Specific ARARs
- Compliance With Location-Specific ARARs
- Compliance With Other Criteria, Advisories, and Guidances

LONG-TERM EFFECTIVENESS AND PERMANENCE

- Magnitude of Residual Risk
- Adequacy and Reliability of Controls

REDUCTION OF TOXICITY MOBILITY, AND VOLUME THROUGH TREATMENT

- Treatment Process Used and Materials Treated
- Amount of Hazardous Materials Destroyed or Treated
- Degree of Expected Reductions in Toxicity, Mobility, and Volume
- Degree to Which Treatment Is Irreversible
- Type and Quantity of Residuals Remaining After Treatment

SHORT-TERM EFFECTIVENESS

- Protection of Community During Remedial Actions
- Protection of Workers During Remedial Actions
- Environmental Impacts
- Time Until Remedial Action Objectives Are Achieved

IMPLEMENTABILITY

- Ability to Construct and Operate the Technology
- Reliability of the Technology
- Ease of Undertaking Additional Remedial Actions, if Necessary
- Ability to Monitor Effectiveness of Remedy
- Ability to Obtain Approvals From Other Agencies
- Coordination With Other Agencies
- Availability of Offsite Treatment, Storage, and Disposal Services and Capacity
- Availability of Necessary Equipment and Specialists
- Availability of Prospective Technologies

COST

- Capital Costs
- Operating and Maintenance Costs
- Present Worth Cost

STATE ACCEPTANCE

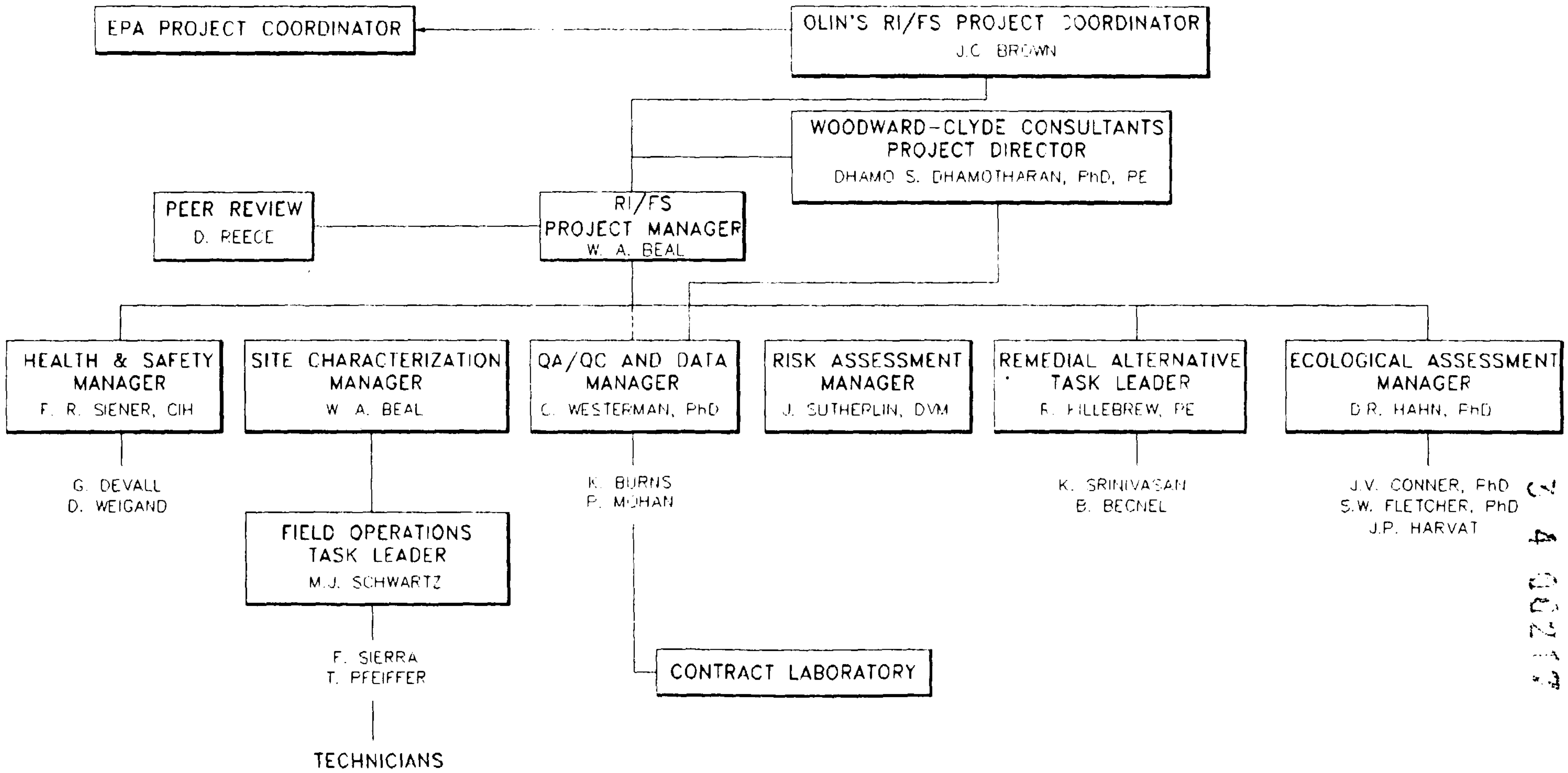
COMMUNITY ACCEPTANCE

REFERENCE: ENVIRONMENTAL PROTECTION AGENCY (EPA)

Office of Solid Waste and Emergency Response (OSWER), Directive 9355-3-01, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Fund, October, 1988.

RI/FS McINTOSH PLANT SITE OLIN CHEMICAL CORPORATION CHARLESTON, TENNESSEE	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana SCALE: / DRAWN BY: SB / DATE: 12-90 CHKD. BY: [illegible] / DATE: 5/23/91	DETAILED ALTERNATIVE ANALYSIS	FILE NO. 90B449C FIG NO. 15

PROJECT ORGANIZATION CHART



RI/FS OLIN'S
McINTOSH PLANT SITE
Woodward-Clyde Consultants

FILE NO: 90B449C-PH2
FIGURE NO.: 17

APPENDIX A

POTENTIOMETRIC SURFACE MAPS, ALLUVIAL AQUIFER (OCTOBER 1987 AND FEBRUARY 1989)

APPENDIX B

AVAILABLE BORING LOGS/MONITOR WELL CONSTRUCTION INFORMATION (RCRA QUARTERLY MONITOR WELLS AND WELLS SAMPLED FOR RI/FS)

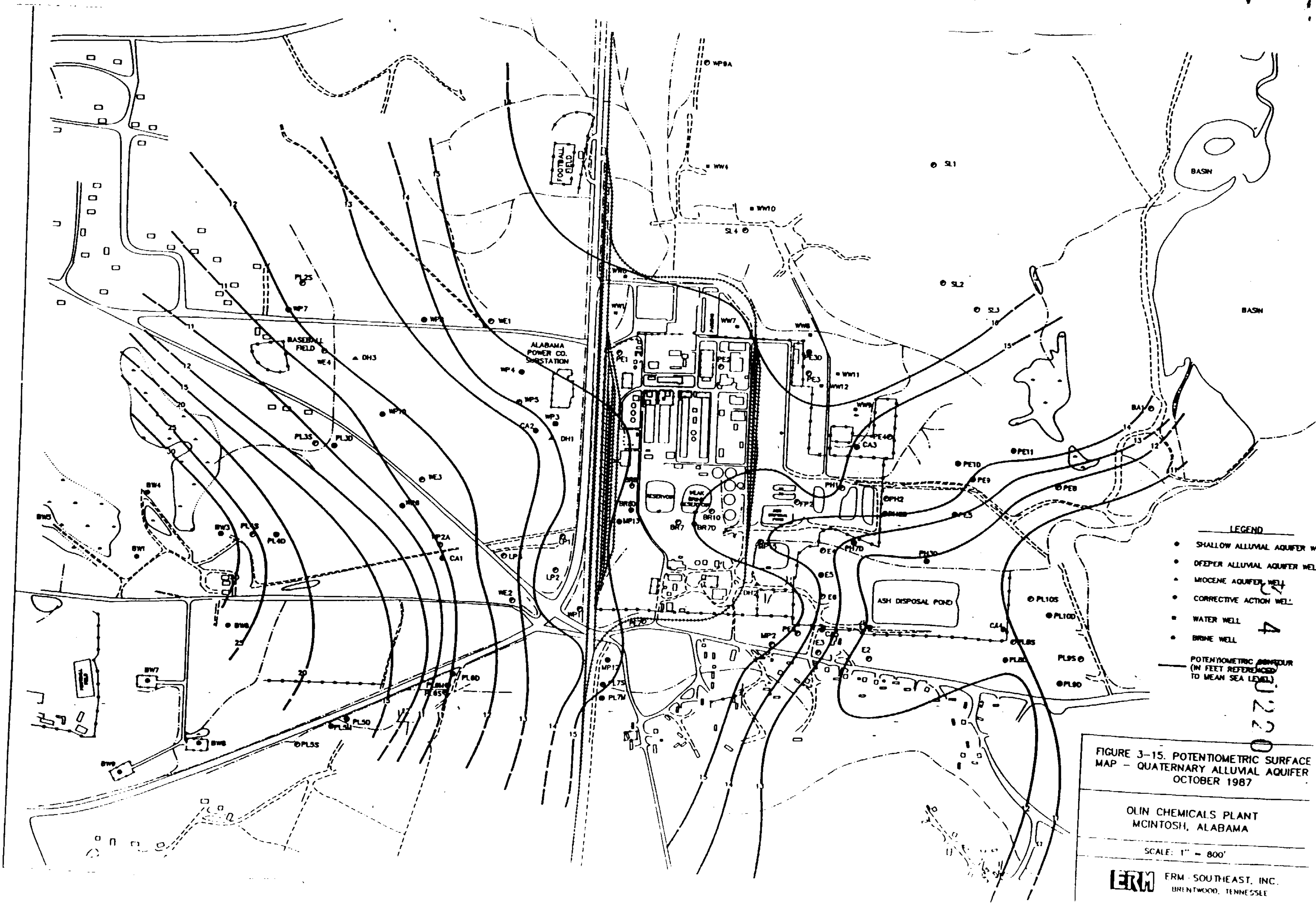


FIGURE 3-15. POTENTIOMETRIC SURFACE MAP – QUATERNARY ALLUVIAL AQUIFER OCTOBER 1987

OLIN CHEMICALS PLANT
MCINTOSH, ALABAMA

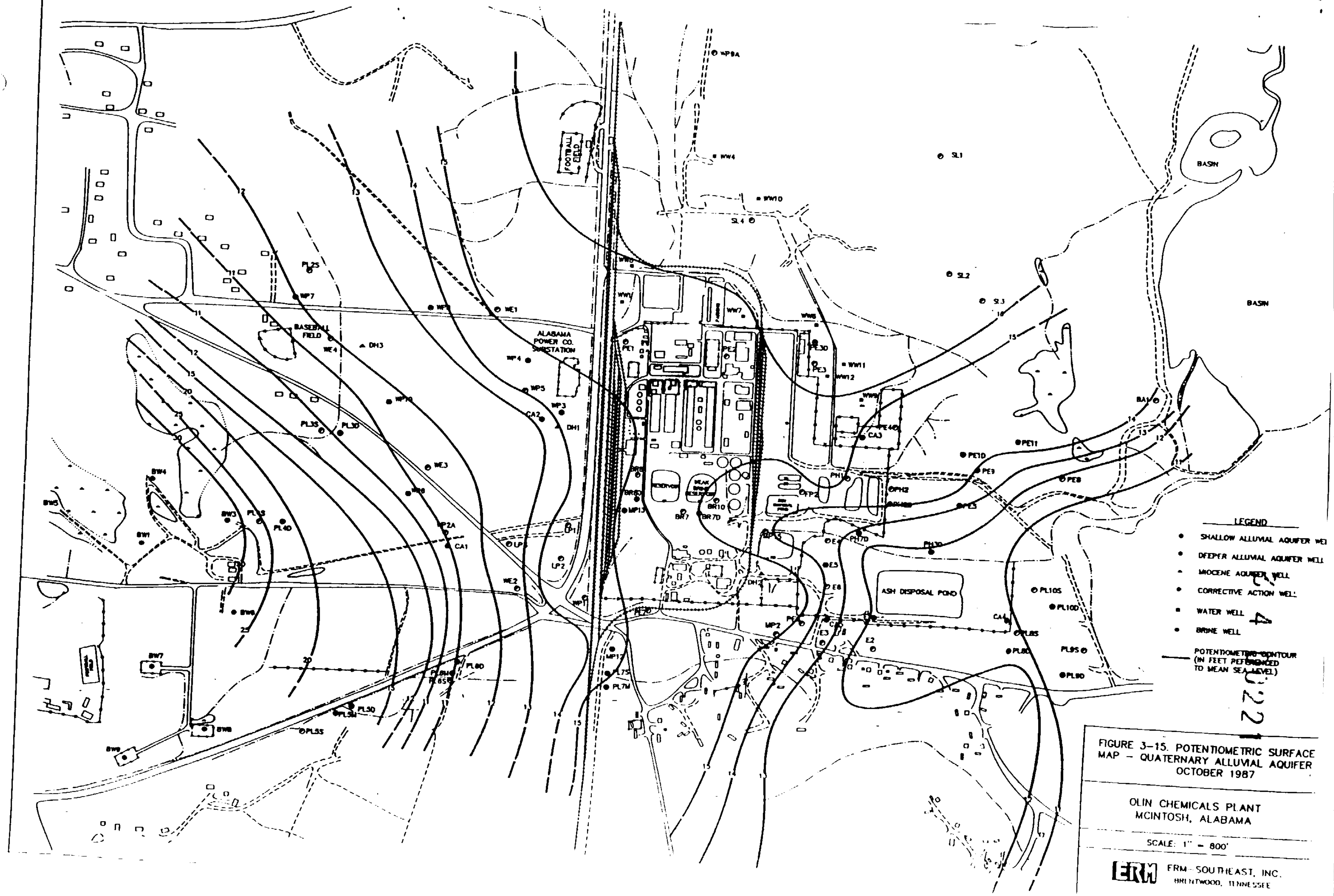


FIGURE 3-15. POTENTIOMETRIC SURFACE MAP - QUATERNARY ALLUVIAL AQUIFER OCTOBER 1987

OLIN CHEMICALS PLANT
MCINTOSH, ALABAMA

SCALE: 1" = 800'

ERM ERM-SOUTHEAST, INC.
BRENTWOOD, TENNESSEE

4
022

VESTER J. THOMPSON, JR., INC.
ENGINEERS TESTING LABORATORIES
MOBILE, ALABAMA — PASCAGOULA, MISSISSIPPI

3 4 00222

TEST BORING LOG

Olin Chemical

GROUND ELEVATION: ----

JECT: Groundwater Monitoring Wells

DATUM: Present Ground Surface

3 NO.: 3071-80-255-E

DATE DRILLED: 12/19/80

GR. WATER DEPTH: ----

RING NO.: B-54 BR-8

LOCATION: As Directed

TYPE BORING: ASTM D-15

DEPTH IN FEET	DESCRIPTION	NO.	BLOWS PER FT. NO	% W.C.	ATTERBERG LIMITS L. L.	P. I.
0	FIRM fine brown SAND	1	16			
5	STIFF red, tan, and gray SILTY CLAY	2	9			
10		3	9			
		4	10			
20		5	13			
25		6	12			
30	FIRM to DENSE fine medium to fine tan SAND	7	17			
35		8	17			
40		9	29			
45		10	27			
		11	37			
55	B.T. @ 51.5'					

VESTER J. THOMPSON, JR., INC.
MATERIALS AND SOILS MECHANICS LABORATORIES
3707 COTTAGE HILL ROAD – MOBILE, ALABAMA 36609

B R-8

FIELD ENGINEER'S LOG

3 4 00223

For: Olin   Report No.

Our Order No.

Name of Project: Sheet No.   of

Boring No. B54   Field Engineer David Malcolm   Date Dec. 19, 1980

Ground Elev.   Datum   Gr. Water Elev.

Sample No.	Sample Depth—Feet From	Sample Depth—Feet To	Depth Stratum Feet From	Depth Stratum Feet To	Visual Classification	*Blows Per 6" 1st	*Blows Per 6" 2nd	*Blows Per 6" 3rd	
1.	0.0	1.5	0.0		Fine Brown Sand	7	8	8	16
2.	5.0	6.5	3.0	3.0	Tan, Gray & Red Silty Clay	8	4	5	[illegible]
3.	10.0	11.5			Tan & Gray Silty Clay	3	4	5	[illegible]
4	15.0	16.5			Tan Silty Clay	4	5	5	1[illegible]
5	20.0	21.5			Tan & Gray Silty Clay	4	5	8	13
6	25.0	26.5	27.0	27.0	" " " "	5	6	6	12
7.	30.0	31.5			fine tan clay sand	4	7	10	1[illegible]
8.	35.0	36.5			Med Tan Sand	10	9	8	1[illegible]
9.	40.0	41.5			Med to Coarse Tan Sand w/Pea Gravel	13	15	14	2[illegible]
10.	45.0	46.5			Med Gray Sand	9	12	15	2[illegible]
11.	50.0	51.5		51.5	Med Gray Sand	10	15	22	3[illegible]

* Number of blows of 140 lb. hammer dropped 30 inches to drive 2 in. split-spoon sampler.

Remarks:

By
Field Engineer

3 4 00224

SOIL & MATERIAL ENGINEERS, INC.
SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: E-1

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 5-29-82 Boring Depth: 105' Static Water Level:

Date Completed: 5-31-82 Well Depth: 85 Permeability Tests: Slug Test

Drilling Method: Rotary Casing: 2", 0-75 Chemical Analysis: EPS Labs

Development Method: Air surge Flush with fresh water

Soil Samples: Spl. Spn. Screen: 75-89

Geophysical Logs: G(S&ME) Grout and Seal: 0-58, 58-66

Depth Ft.	Elev. 46.34		Description	Penetration – Blows per ft: 5 10 20 30 40 60 80
			From 0-50 see log E-2	
			Lost 50% circulation @ 28'	
50			SAND: Tan and white very fine to fine with some coarse to very coarse quartzose slightly cherty sub-angular to sub-rounded trace very fine gravel some very fine black minerals contact in spoon	
55			Red-brown and tan fine to medium with some coarse and very coarse quartzose slightly cherty sub-angular to sub-rounded with trace of fine gravel	
60			Tan with some orange-brown fine to very coarse quartzose slightly cherty sub-augular to sub-rounded with trace fine to medium gravel portions contain orange-brown sandy clay	
			Lost 100% circulation @ 62' got returned @ 73'	
65			White light gray and tan fine to very coarse quartzose trace of chert sub-angular to sub-rounded with small	
70			SAND AND GRAVEL: Light gray and tan fine to very coarse quartzose cherty sub-angular to sub-rounded fine to large gravel and portions contains light gray sandy clay	

3 4 00225

SOIL & MATERIAL ENGINEERS, INC.

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: E-1

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 5-29-82 Boring Depth: 105' Static Water Level:

Date Completed: 5-31-82 Well Depth: 85 Permeability Tests: Slug test

Drilling Method: Rotary Casing: 2", 0-75 Chemical Analysis: EPS Labs

Development Method: Air surge Flush with fresh water

Soil Samples: Spl. Spn. Screen: 75-89

Geophysical Logs: G(S&ME) Grout and Seal: 0-58, 58-66

Depth Ft.	Elev.		Description	Penetration – Blows per ft (5 10 20 30 40 60 80)
80				
85				
			CLAY: Gray and greenish brown mottled silty fine very sandy plastic with trace of small gravel	
90				
95				
100				
			Total Depth: 105'	

3 4 00226

SOIL & MATERIAL ENGINEERS, INC.
SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: E-2

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 5-20-82 Boring Depth: 50' Static Water Level:

Date Completed: 5-20-82 Well Depth: 50 Permeability Tests: Slug test

Drilling Method: Auger Boring Casing: 2", 0-45 Chemical Analysis: EPS Labs

Development Method: Air surge

Soil Samples: Spl. Spn. Screen: 45-50

Geophysical Logs: G(S&ME) Grout and Seal: 0-33, 33-37

Depth Ft.	Elev. 46.31		Description	Penetration — Blows per ft: 5 10 20 30 40 60 80
0–17			CLAY: Gray tan and yellow-brown mottled silty with trace of fine sand plastic	
17–22			SILT: White and yellow-brown mottled very fine to fine very sandy sub-angular to sub-rounded trace of mica and black minerals	
22–33			SAND: White and yellow-brown very fine to fine quartzose sub-angular to sub-rounded very silty abundant black minerals trace of mica	
			See next page	

4 00227

SOIL & MATERIAL ENGINEERS, INC.
SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: E-2

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 5-20-82 Boring Depth: 50' Static Water Level:

Date Completed: 5-20-82 Well Depth: 50' Permeability Tests: Slug test

Drilling Method: Auger boring Casing: 2", 0-45 Chemical Analysis: EPS Labs

Development Method: Air surge

Soil Samples: Spl. Spn. Screen: 45-50

Geophysical Logs: G(S&ME) Grout and Seal: 0-33, 33-37

Depth Ft.	Elev.		Description	Penetration – Blows per ft (5 10 20 30 40 60 80)
30–42			SAND: Tan and yellow-brown very fine to fine with some medium quartzose sub-angular to sub-rounded slightly silty with some black minerals and trace of mica	
42–48			Yellow-brown fine to coarse sub-angular to sub-rounded quartzose with trace of mica grading into CLAY: gray plastic coarse and very coarse sandy	
48–50			Light brown fine to medium with some coarse and very coarse quartzose sub-angular to sub-rounded*	
50			**Total Depth: 50'** *with trace of mica and black minerals	

3 4 00228

SOIL & MATERIAL ENGINEERS, INC.

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: E-4

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 5-17-82 Boring Depth: 50' Static Water Level:

Date Completed: 5-17-82 Well Depth: 50 Permeability Tests: Slug Test

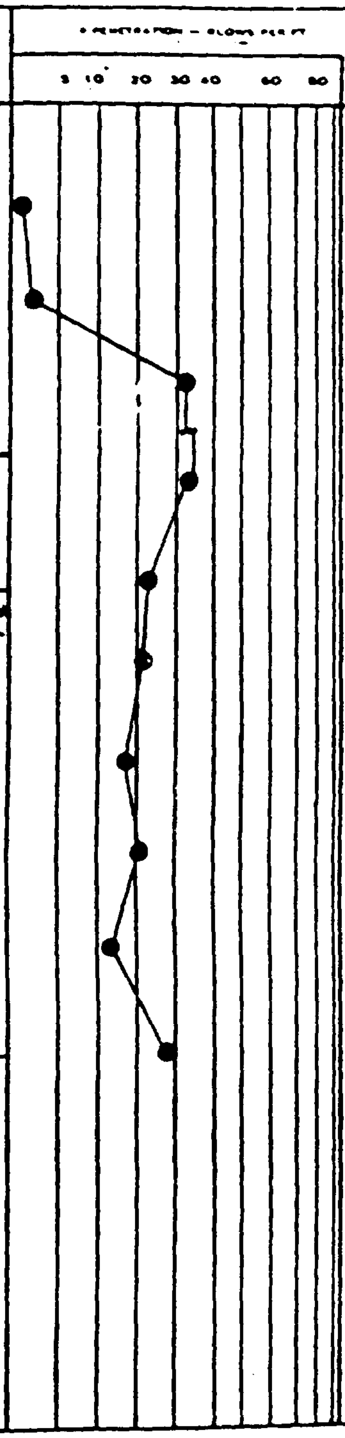
Drilling Method: Rotary Casing: 2", 0-45 Chemical Analysis: EPS Labs

Development Method: Air surge Flush with fresh water

Soil Samples: Spl. Spn. Screen: 45-50

Geophysical Logs: G(S&ME) Grout and Seal: 0-34, 34-38

Depth Ft.	Elev. 37.22		Description
5, 10			CLAY: Gray red-brown mottled silty fine to medium slightly sandy plastic organic odor very strong
15			SILT: Yellow-brown very fine to fine sandy clayey odor very strong
20			SAND: Light gray very fine to fine quartzose sub-angular to sub-rounded slightly micaceous silt odor not as strong
25			Light gray fine to medium sub-angular to sub-rounded quartzose slightly cherty slightly micaceous trace of fine black minerals odor seems to be*
30			Tan and yellow brown medium to very coarse sub-angular to sub-rounded quartzose slightly cherty with fine black minerals
35			Tan fine with some medium quartzose slightly cherty sub-angular to sub-rounded trace of fine black minerals
40, 45, 50			Tan and white fine to very coarse quartzose cherty sub-angular to sub-rounded with fine to large gravel
55, 60, 65			Total Depth: 50' *getting weaker with depth Boring was originally designed as a deep boring because of presence of organics, well was modified to shallow



SOIL & MATERIAL ENGINEERS, INC. 00229

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: E-5

Logged by: L. Carter Drilled by: Graves Grid Coord.: Lat.-Long.:

Date Started: 8-10-82 Boring Depth: 80' Static Water Level:

Date Completed: 8-12-82 Well Depth: 75.2 Permeability Tests: Slug Test

Drilling Method: Rotary Casing: 2", 0-65.2 Chemical Analysis: EPS Labs

Development Method: Air surge Flush with fresh water

Soil Samples: Cuttings Screen: 62.5 - 75.2

Geophysical Logs: G(S&ME) Grout and Seal: 0-60, 60-62

Depth Ft.	Elev. 38.32		Description	Penetration – Blows per ft: 5 10 20 30 40 60 80
0–50			For 0-50 see E-4 log	
50–58			SAND: White and tan very fine to fine quartzose slightly cherty sub-angular to sub-rounded with abundant fine black minerals slightly clayey	
58–70			SAND AND GRAVEL: Very fine to medium quartzose slightly cherty sub-angular to sub-rounded with fine quartz and cherty gravel	

See next page

SOIL & MATERIAL ENGINEERS, INC. 4 00230
SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: E-5

Logged by: L. Carter Drilled by: Graves Grid Coord.: Lat.-Long.:

Date Started: 8-10-82 Boring Depth: 80' Static Water Level:

Date Completed: 8-12-82 Well Depth: 75.2 Permeability Tests: Slug Test

Drilling Method: Rotary Casing: 2", 0-65.2 Chemical Analysis: EPS Labs

Development Method: Air surge Flush with fresh water

Soil Samples: Cuttings Screen: 65.2 - 75.2

Geophysical Logs: G(S&ME) Grout and Seal: 0-60, 60-62

Depth Ft.	Elev.		Description	Penetration — Blows per ft: 5 10 20 30 40 60 80
75			SAND AND CLAY: Gray very fine to fine sand quartzose with light gray sticky clay	
80			CLAY: Gray plastic very fine to fine sandy	
85				
90–135			Total Depth: 80'	

SOIL & MATERIAL ENGINEERS, INC. 4 00231

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-07ZA Boring or Well No.: E-6

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 5-16-82 Boring Depth: 50' Static Water Level:

Date Completed: 5-16-82 Well Depth: 42.8 Permeability Tests:

Drilling Method: Auger Boring Casing: 2", 0-43.5 Chemical Analysis: EPS Labs

Development Method: Air surge

Soil Samples: Cuttings Screen: 42.8-48.8

Geophysical Logs: G(S&ME) Grout and Seal: 0-24, 24-28

Depth Ft.	Elev. 45.45		Description	Penetration — Blows per ft. (5 10 20 30 40 60 80)
0–21			CLAY: Red-brown and gray mottled fine slightly sandy silty plastic	
21–50			SAND: Yellow-brown and white very fine to fine with some medium sub-angular to sub-rounded quartzose	
50			Total Depth: 50' Auger Boring	

SOIL & MATERIAL ENGINEERS, INC.

4 00232

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: MP-8

Logged by: L. Carter Drilled by: Graves Grid Coord.: Lat.-Long.:

Date Started: 7-21-82 Boring Depth: 95' Static Water Level:

Date Completed: 7-23-82 Well Depth: 83.8 Permeability Tests:

Drilling Method: Rotary Casing: 2", 0-78.8 Chemical Analysis: EPS Labs

Development Method: Air surge

Soil Samples: Spl. Spn. Screen: 78.8 - 83.8

Geophysical Logs: G(S&ME) Grout and Seal: 0-71,71-75

Depth Ft.	Elev.		Description
			For 0-60 see MP-9 log
60			SAND: Light gray fine to very coarse sub-angular to sub-rounded quartzose slightly cherty with interbedded gray fine to very coarse sandy plastic* Yellow-brown fine to very coarse sub-angular to sub-rounded quartzose slightly cherty clayey with trace of gravel (slight organic odor)
70			SILT: Medium gray micaceous fine sandy slightly clayey with trace of gravel (slight organic odor)
75			CLAY: Medium gray very silty very micaceous fine very sandy medium plasticity
80		◀	SAND AND GRAVEL: Medium gray fine to coarse quartzose sub-angular to sub-rounded sand and fine to medium gravel
85			SILT: Light gray very fine to medium very sandy clayey micaceous
90			CLAY: Medium gray and green mottled fine slightly sandy very silty high plasticity
95			Total Depth: 95'

*clay with trace of gravel (organic odor)

SOIL & MATERIAL ENGINEERS, INC.4 00233

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: MP-9

Logged by: L. Carter Drilled by: S&ME Grid Coord.: ______ Lat.-Long.: ______

Date Started: 6-21-82 Boring Depth: 60' Static Water Level: ______

Date Completed: 6-22-82 Well Depth: 52 Permeability Tests: Slug test

Drilling Method: Auger Boring Casing: 2", 0-47 Chemical Analysis: EPS Labs

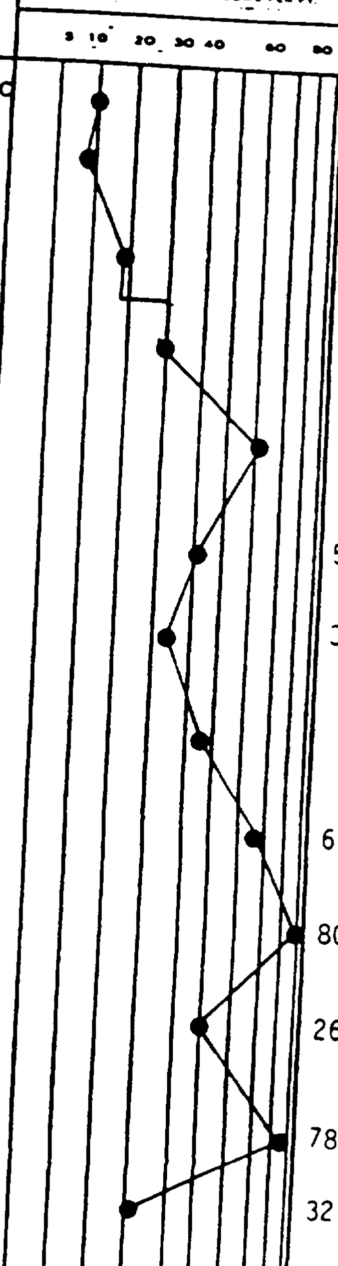
Development Method: Air surge

Soil Samples: Spl. Spn. Screen: 47.52

Geophysical Logs: G(S&ME) Grout and Seal: 0-39, 39-43

Depth Ft.	Elev. 45.48	Description
0–15		CLAY: Red-brown silty fine slightly sandy plastic
15–19		SAND: Red-brown very fine to fine quartzose sub-angular to sub-rounded silty slightly clayey
19–29		Multi-colored very fine to fine quartzose sub-angular to sub-rounded silty
29–48		Tan and brown fine to medium quartzose slightly cherty sub-angular to sub-rounded silty
48–60		Gray fine to very coarse quartzose cherty sub-angular to sub-rounded very clayey
60		Total Depth: 60'

Penetration — Blows per ft.



SOIL & MATERIAL ENGINEERS, INC. 4 00234

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: MP-13

Logged by: L. Carter Drilled by: Graves Grid Coord.: Lat.-Long.:

Date Started: 7-28-82 Boring Depth: 100' Static Water Level:

Date Completed: 7-29-82 Well Depth: 95 Permeability Tests: Slug test

Drilling Method: Rotary Casing: 6", 0-70 2", 0-85 Chemical Analysis: EPS Labs

Development Method: Air surge

Soil Samples: Cuttings Screen: 85-95

Geophysical Logs: G(S&ME) Grout and Seal: 0-79, 79-81

Depth Ft.	Elev. 46.69		Description
0-45			For 0-45 see MP-11 log
45-65			SAND: White with abundant orange grains very fine to medium sub-angular to sub-rounded quartzose slightly cherty very fine black minerals
65-			White multi-colored very fine to very coarse sub-angular to sub-rounded quartzose cherty*

See next page

*trace of medium to fine gravel

SOIL & MATERIAL ENGINEERS, INC. 4 00235

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: MP-13

Logged by: L. Carter Drilled by: Graves Grid Coord.: ______ Lat.-Long.: ______

Date Started: 7-28-82 Boring Depth: 100' Static Water Level: ______

Date Completed: 7-29-82 Well Depth: 95 Permeability Tests: Slug test

Drilling Method: Rotary Casing: 6", 0-70 / 2", 0-85 Chemical Analysis: EPS Labs

Development Method: Air surge

Soil Samples: Cuttings Screen: 85-95

Geophysical Logs: G(S&ME) Grout and Seal: 0-79, 79-81

Depth Ft.	Elev.		Description	Penetration — Blows per ft. (5, 10, 20, 30, 40, 60, 80)
75			SAND: White and multi-colored very fine very coarse sub-angular to sub-rounded quartzose cherty with trace of fine to medium gravel	
80			White very fine to medium with some coarse sub-angular to sub-rounded quartzose slightly cherty abundant very fine black minerals	
85–95		screen		
95			CLAY: Light gray fine to medium sandy	
100			Total Depth: 100'	
105–135				

SOIL & MATERIAL ENGINEERS, INC. 4 00236

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: MP-11

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 6-2-82 Boring Depth: 45' Static Water Level:

Date Completed: 6-2-82 Well Depth: 44 Permeability Tests: Slug test

Drilling Method: Rotary Casing: 2", 0-39 Chemical Analysis: EPS Labs

Development Method: Air surge Flush with fresh water

Soil Samples: Spl. Spn. Screen: 39-44

Geophysical Logs: G(S&ME) Grout and Seal: 0-32, 32-36

Depth Ft.	Elev. 46.67	Description	Penetration – blows per ft.
0–3		CLAY CAP: Brown to red-brown silty very tight	
3–8		White consolidated to loose LIME	13
8–18		RESIDUUM-CLAY: Gray red-brown and yellow mottled slightly silty with trace of fine sand plastic	15, 19
18–22		SAND: gray tan and yellow mottled very fine to fine quartzose sub-angular to sub-rounded quartzose very silty very clayey	23
22–32		White and yellow-brown very fine to fine quartzose sub-angular to sub-rounded silty with black minerals	29, 35
32–39		Orange-brown and tan fine to medium with some coarse quartzose with trace chert sub-angular to sub-rounded with trace of some gravel (organic smell)	41, 22
39–45		Orange-brown fine to coarse quartzose cherty sub-angular to sub-rounded trace of silt with fine*	22

Boring Terminated @ 45'

*to medium gravel

Boring designed as deep. but modified to shallow because of presence of organics

GRINER DRILLING SERVICE, INC.

TELEPHONE 601/736-6347
POST OFFICE DRAWER 825
COLUMBIA, MISS. 39429

3 A 00237

PAGE 1 OF 1 PA

FORMATION LOG FOR Olin Corporation, McIntosh, Alabama

ADDRESS P.O. Box 28 McIntosh, AL 36533

TEST HOLE NO. MP 14

TEST HOLE LOCATION Olin McIntosh Plant

FORMATION AND TEST HOLE INFORMATION

TOTAL DEPTH	THICKNESS EACH STRATUM	FORMATION	REMARKS
5	5	RED FILL DIRT	
10	5	RED CLAY	
15	5	ORANGE TO WHITE CLAY	
20	5	ORANGE TO BROWN CLAY	
25	5	CLAY AND SAND	
45	20	SAND DRY	
70	25	SAND WET	
85	15	SAND AND PEAGRAVEL	
87	2	SAND	
90	3	CLAY	

Date Started 12/1/88 19

Date Completed 12/2/88

Sparky Wilson, Gary Hill Field Engineer

Leland Beach Driller

GRINER DRILLING SERVICE, INC.
TELEPHONE 601/736-6347
POST OFFICE DRAWER 825
COLUMBIA, MISS. 39429

3 4 00238

FORMATION LOG FOR Olin Corporation, McIntosh, AL

ADDRESS P.O. Box 28 McIntosh, AL 36533

TEST HOLE NO. MP 15

TEST HOLE LOCATION Olin McIntosh Plant

FORMATION AND TEST HOLE INFORMATION

TOTAL DEPTH	THICKNESS EACH STRATUM	FORMATION	REMARKS
5	5	DARK BROWN CLAY	
15	10	RED CLAY	
20	5	RED TO BROWN CLAY	
25	5	TAN TO BROWN DRY SAND	
30	5	YELLOW SAND DRY	
35	5	YELLOW-WHITE SAND DRY	
40	5	YELLOW TO BROWN DRY SAND	
45	5	YELLOW SAND WET	
55	10	YELLOW TO WHITE SAND WET	
60	5	YELLOW COARSE SAND WET	
70	10	COARSE SAND	
86	16	SAND AND PEAGRAVEL	
90	4	CLAY	

Date Started 11/30/88 19__ Date Completed 12/1/88 19

Sparky Wilson Gary Hill Field Engineer

Leland Beach Driller

WATER WELL
CONTRACTORS

CONDUCTOR
PIPE SERVICE

GRINER DRILLING SERVICE, INC.
P.O. BOX 1052
MOBILE, ALABAMA 36601
205-479-3510

3 4 00239

Olin Corporation

Monitoring Well Completion Data

Monitoring Well No.	MP 14	MP 15
Total depth:	90'	90'
Bottom of 2" PVC Screen:*	86'	84'
Top of 2" PVC Screen:	76'	74'
Top of Gravel Pack:**	71'	70'
Top of Bentonite Seal:***	67'	66'
Grout to Surface, No. of Sacks:	16	17

* Screen manufactured by Johnson Well Equipment Co., Pensacola, FL. Slot Size: No. 10.

** Gravel Pack is a Colorado Silica No. 10-20. Approximatively 40 gallon of pack used per well.

*** Five gallons of ¼" bentonite pellets used per well. 6 5/8" steel casing protector with locking aluminum caps were installed over each 2" PVC well.

All wells were drilled by the hollowstem auger method.

If you have any questions or if I can be of any further assistance please give me a call. Thanks again for the opportunity to work at the Olin McIntosh Plant.

Sincerely,

Griner Drilling Service, Inc.,

Sparky Wilson

Sparky Wilson

VESTER J. THOMPSON, JR., INC.
MATERIALS AND SOILS MECHANICS LABORATORIES
3707 COTTAGE HILL ROAD – MOBILE, ALABAMA 36609

3 4 00240

FIELD ENGINEER'S LOG

For: ______________________ Report No. ______
______________________ Our Order No. ______
Name of Project: ______________________ Sheet No. ______ of ______
Boring No. #26 Field Engineer ______________ Date ______
Ground Elev. ______ Datum ______ Gr. Water Elev. ______

Sample No.	Sample Depth—Feet From	Sample Depth—Feet To	Depth Stratum Feet From	Depth Stratum Feet To	Visual Classification	*Blows Per 6" 1st	2nd	3rd
	PE 5		0	18.0	med red & orange clay & clay sand			
			18.0	35.0	med orange & tan sand			
			35.0	38.0	med to course white sand			
					screen set at 38.0"			
~~#~~ ?	5 3		0	1.5	med orange clay sand			
33A			1.5	25	med gray silty clay sand			
			25 —					
					set screen at 48.0			
#1B								
			0	1.5	med red clay sand			
	PE 5		1.5	2.0	Fine gray silty sand Clay			
			2.0	7.0	Fine Tan sand Clay			
			7.0	17.0	Tan silty Clay			
			17.0	23.0	Fine gray silty sand Clay			
			23.0					
					48.0			

* Number of blows of 140 lb. hammer dropped 30 inches to drive 2 in. split-spoon sampler.

Remarks: ______________________

______________________ By ______________
Field Engineer

CONTRACTOR - VESTER J. THOMPSON

3 4 00241

NEW RCRA WELLS

(25 ft per screen, 4" diameter casing)

PE-3D

10/26/83

0-12	Multicolored clay
12-21	Yellow medium
21-41	Yellow medium sand/fine gravel
41-61	Yellow medium sand/fine gravel
61-73	Yellow sand/coarse gravel
73	Gray clay

3 4 00242

NEW RCRA WELLS

(25 ft per screen, 4" diameter casing)

pH-2D

10/27/83

0-12	Multicolored clay
12-21	Coarse yellow sand
21-35	Coarse yellow sand
35-55	Coarse yellow sand & small gravel
55-73	Coarse yellow sand
73-80	Sandy clay (gray)

NEW RCRA WELLS

3 4 00243

(25 ft per screen, 4" diameter casing)

pH-3D

10/27/83

0-14	Multicolored clay
14-21	Coarse yellow sand
21-35	Coarse yellow sand
53-71	Yellow sand/fine gravel
71-74	Sandy gray clay

NEW RCRA WELLS

(25 ft per screen, 4" diameter casing)

pH-7D

10/28/83

0-10	Multicolored clay
10-21	Yellow medium sand
21-30	Yellow coarse sand
30-55	Yellow coarse sand/fine gravel
55-73	Yellow coarse sand/coarse gravel
73-75	Sandy gray clay

3 4 00245

Olin Chemical Company
P.O. Box 28
McIntosh, Alabama 36533

May 26, 1983

BY: Graves Well Drilling Company, Inc.
P.O. Box 225
Sylacauga, Alabama 35150

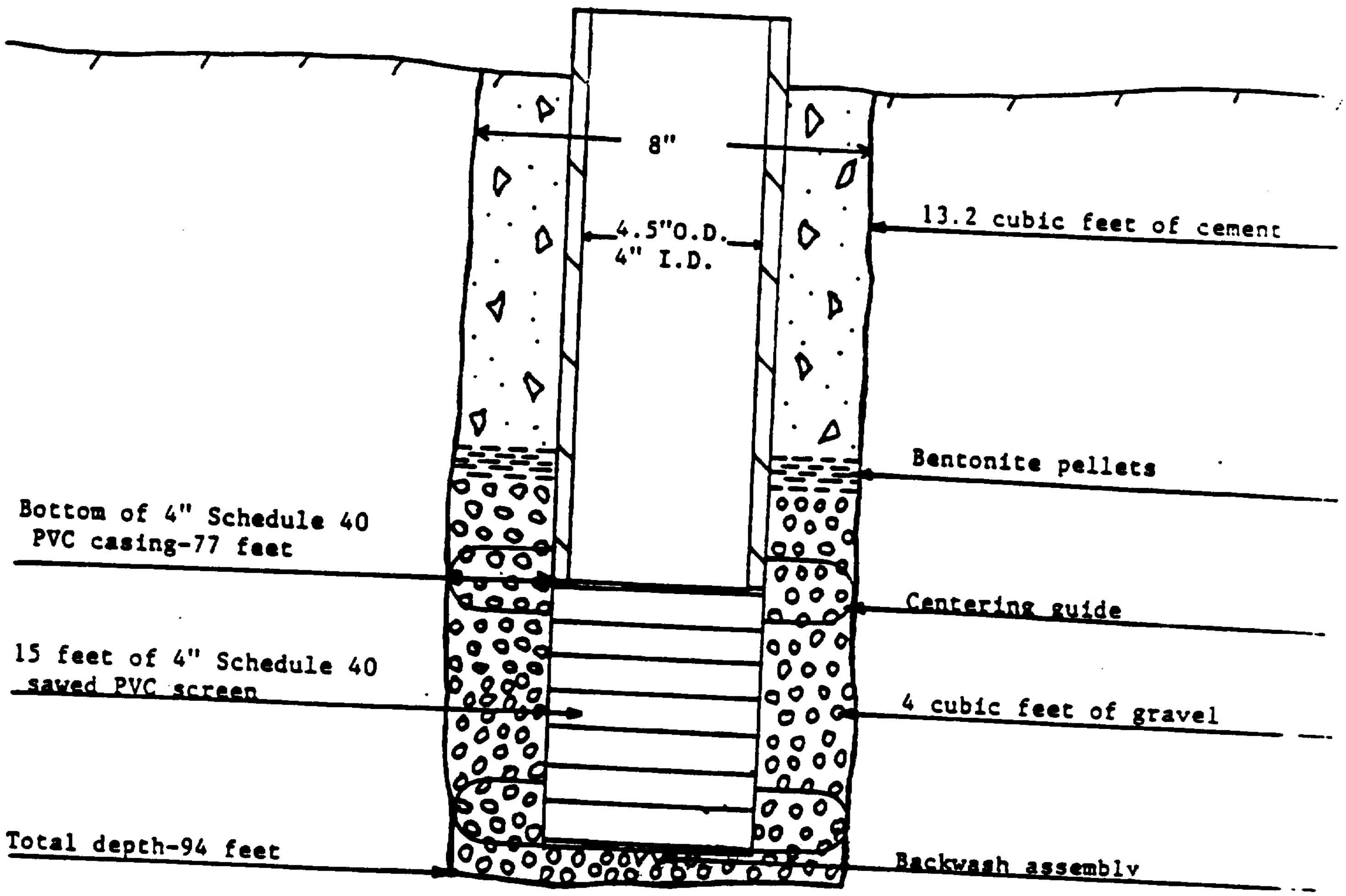
Rig #191
Job: 146
Well # P.L.4D

0-10'	multiple color clay
10-25'	gray sand
25-40'	coarse gray sand
40-55'	coarse gray sand
55-70'	coarse gray sand
70-85'	coarse gray sand
85-90'	coarse gray sand
90-92'	clay

77' of 4" PVC casing
15' of 4" PVC screen .010
4 sacks gravel

GRAVES WELL DRILLING CO., INC.
P.O. BOX 225
SYLACAUGA, AL 35150
205/245-6379

3 4 00046

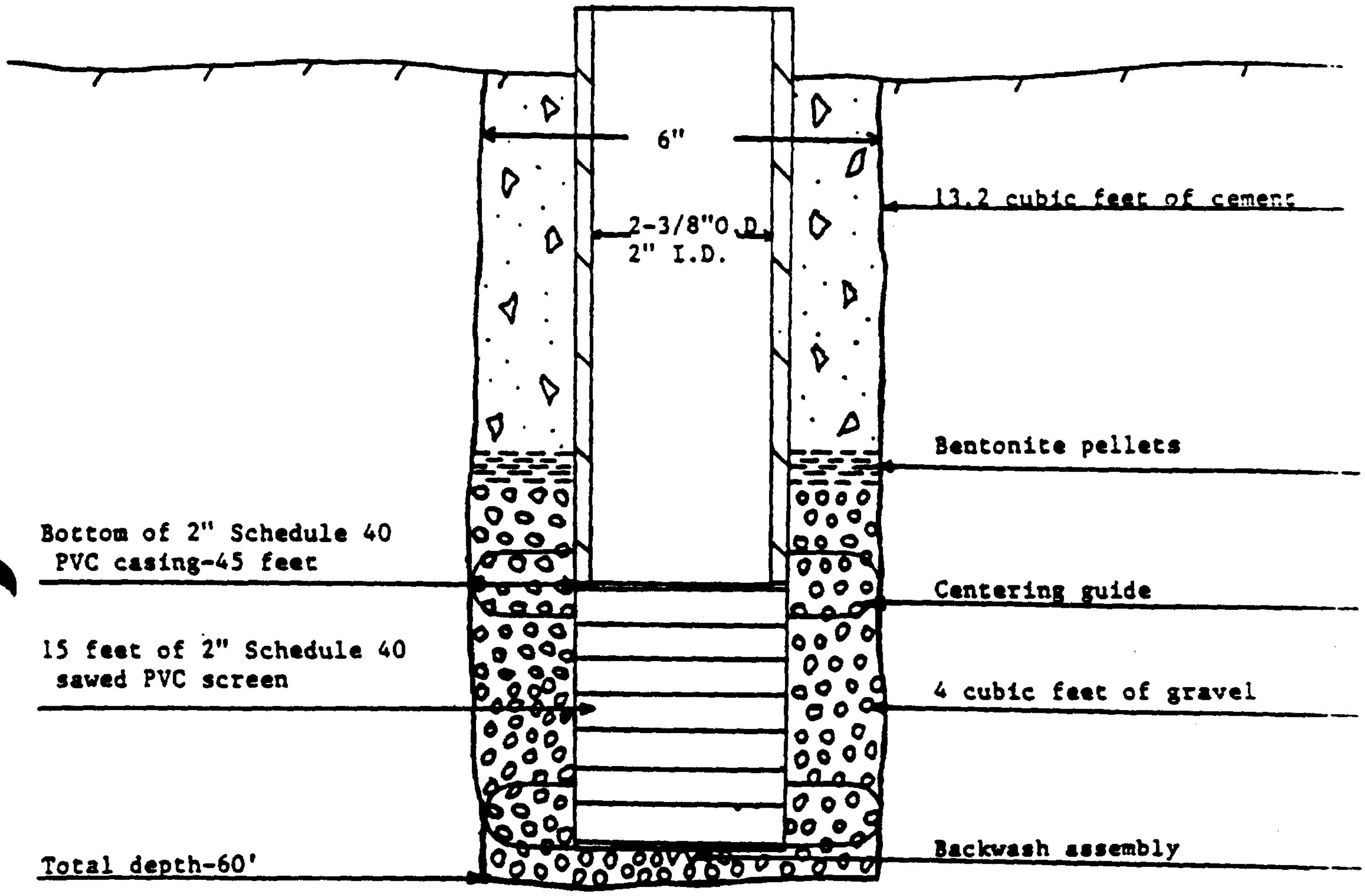


DATE	: July 5, 1983
DRAWN BY	: Wendell Beavers
	Olin Chemical Co.
WELL NAME	: PL-4-D
LOCATION	: McIntosh, AL

GRAVES WELL DRILLING CO., INC.
P.O. BOX 225
SYLACAUGA, AL 35150

205/245-6379

3 4 00247

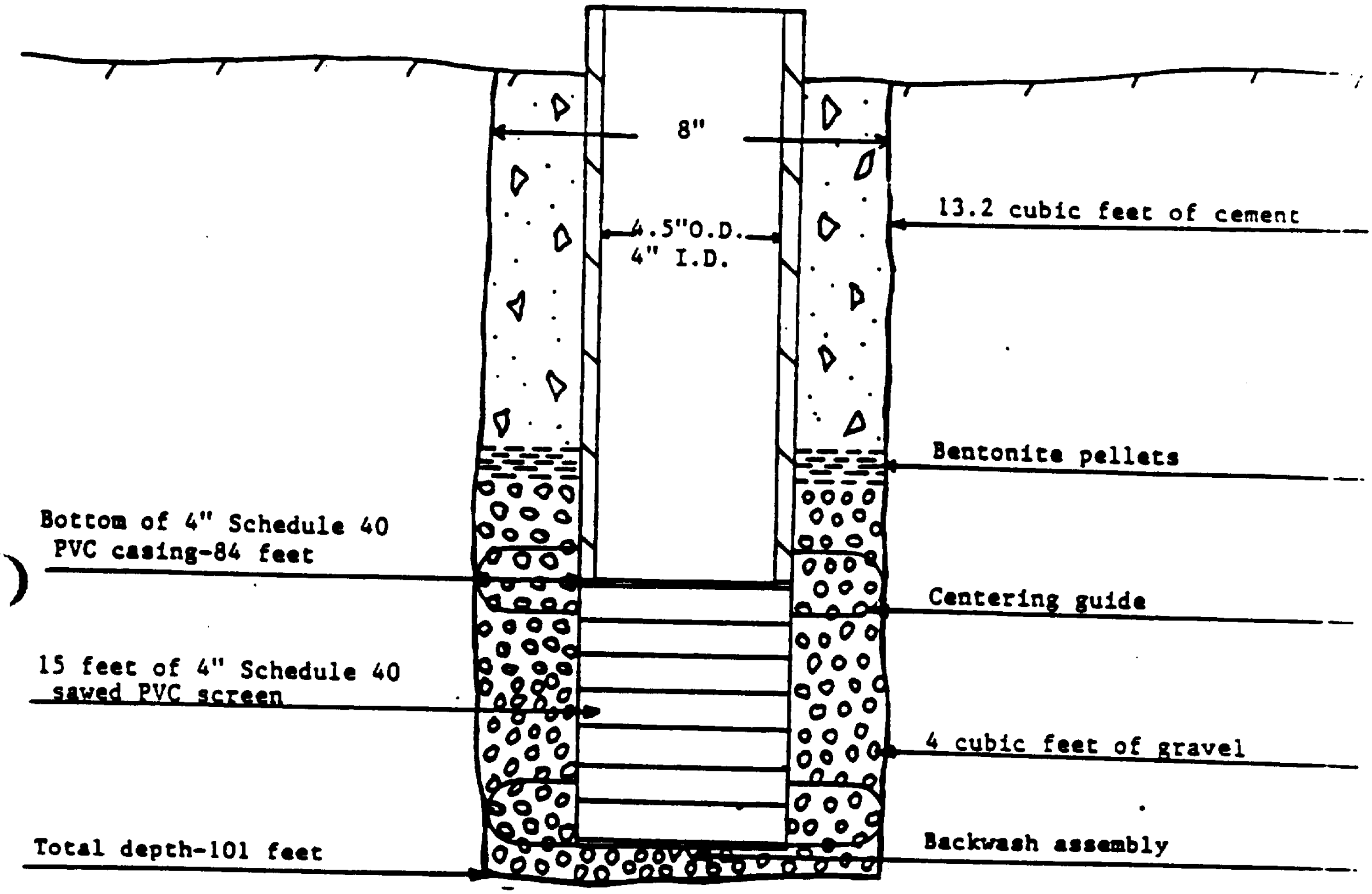


DATE	: July 5, 1983
DRAWN BY	: Wendell Beavers
	Olin Chemical C.
WELL NAME	: PL-4-S
LOCATION	: McIntosh, AL

GRAVES WELL DRILLING CO., INC.
P.O. BOX 225
SYLACAUGA, AL 35150

205/245-6379

3 4 00248



DATE	: July 5, 1983
DRAWN BY	: Wendell Beavers
	Olin Chemical Co.
WELL NAME	: PL-5-D
LOCATION	: McIntosh, AL

3 4 00249

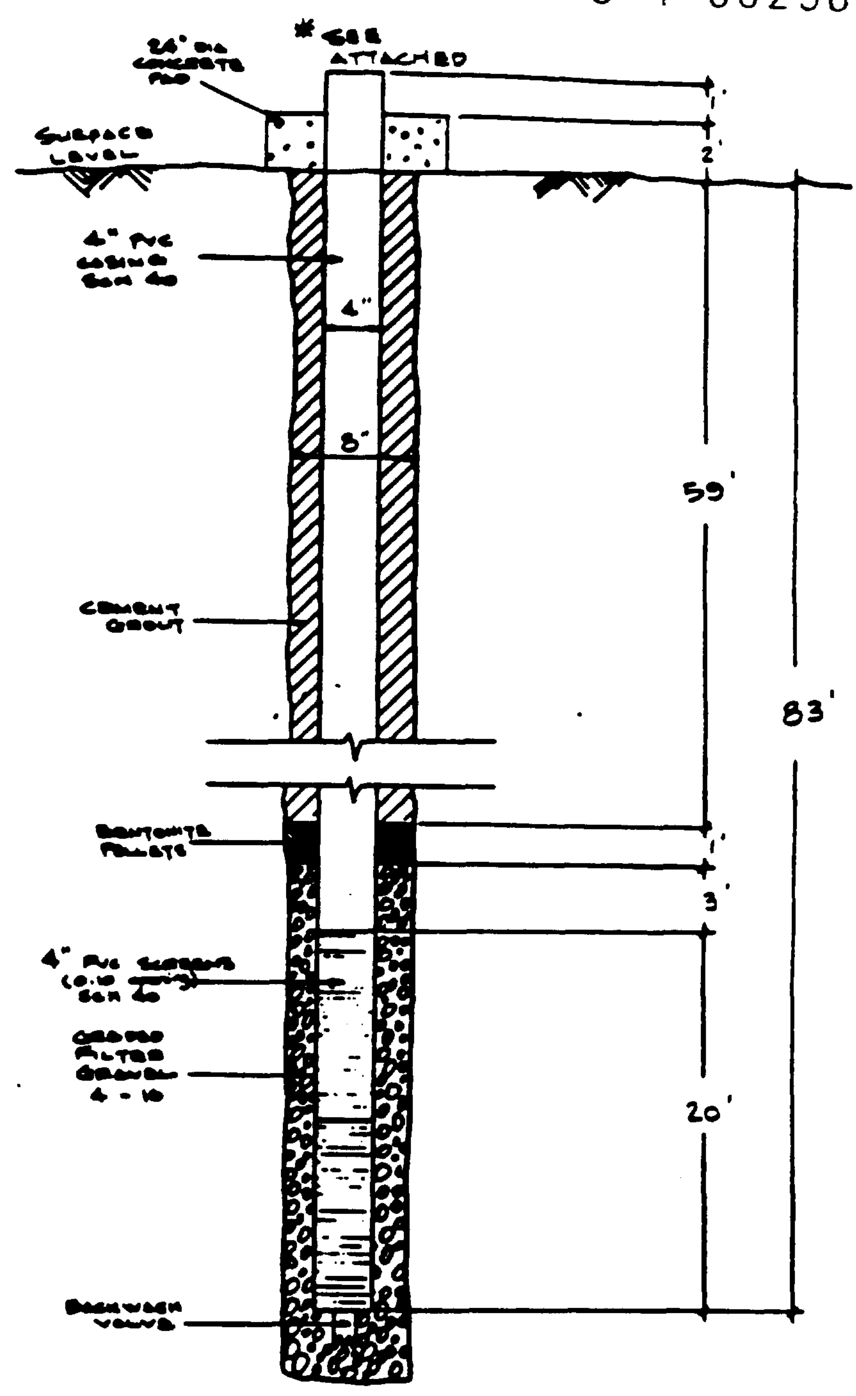
Olin Chemical Company
P.O. Box 28
McIntosh, Alabama 36533
May 27, 1983

By: Graves Well Drilling Company, Inc.
P.O. Box 225
Sylacauga, Alabama 35150

Rig #191
Job #146
Well # P.L.5D

0-10'	multiple color clay
10-20'	fine white sand
20-40'	medium sand white
40-51'	medium sand white
51-64'	gravel coarse sand
64-66'	blue clay
66-73'	blue clay
73-77'	fine white sand
77-81'	gravel and sand
81-96'	sand and gravel
96-99'	sand and gravel
99-101'	two foot of blue clay

3 4 00250



NOTE — SUBMERSIBLE PUMP SET 47 FEET BELOW TOP OF PIPE.

NOT TO SCALE

Graves Well Drilling Co.
PROJECT OLIN CHEMICAL
WELL # — PL8D
McINTOSH, AL

BY 3P	APPROVED MC	DATE 2/26/85

Graves Well Drilling Company Inc. P.O. Box 225. Sylacauga,Ala. 35150

DRILLING CONTRACTOR | License Number | Address | Zip Code | Date

Olin Chemical Company, P.O. Box 28, McIntosh,Ala. 36553

PROPERTY OWNER | Address (mailing) | Zip Code

3 4 00251

Washington County	27		T3N	R1E
WELL LOCATION: County	Section	¼ Section	Township	Range

Distance and direction from nearest town, community, road junction or other reference point

WELL WILL BE USED FOR: ☐ Private supply ☐ Public supply ☐ Industrial supply ☐ Test well ☐ Irrigation Other: Monitoring Well PL8D

2--14-85 Estimated starting date

Drilling method: (check) Cable tool; Rotary X; Jetted; Bored; Other:

4" Diameter of well

100' Estimated depth

Mel Adams

SIGNATURE of Drilling Contractor

Total Depth 83½'

Completion Date February 14,1985

Interval	Description of cuttings	Interval	Description of cuttings
0-1'	yellow sandy clay		
1-14'	red clay		
14-40'	fine yellow sand		
40-57'	medium yellow sand and match head gravel		
57-83'	coarse yellow sand and match head gravel		
83-83½'	gray clay		
	Total Depth: 83½'		
	66' of 4" PVC casing		
	20' of 4" PVC Screen .010		
	Air Test: 50 GPM @63-83'		
	SL: 27'		

Completion data: report depths below ground level

Pump
Type: ☐ Turb. ☐ Subm. ☐ Jet ☐ Cyl.; Other: ___
Intake depth ___ H.P. ___ Yield ___ gpm

Capacity
Tested by: ☐ pumping ☐ air lift ☐ bailer ☐ none
Measured Static Water Level ___ ft.
Measured pumping level ___ ft. after ___ hrs. pumping ___ gpm
Development time prior to testing ___ hrs.

Finish
☐ Open hole ☐ Screened ☐ Slotted pipe ☐ Gravel pa
Interval(s) screened: ___ to ___ ft
___ to ___ ; ___ to ___ ft
Packer(s) set at ___ and ___ ft
Screen: diam. ___ ; Size openings ___

Casing

Interval cased	Diam. (inches)	*Type pipe	*Type couplings	Interval grouted

*Couplings: Threaded & Coupled (T&C) Welded (W) Threaded & coupled & welded (TC&W)

Other: ___

*Pipe: Black; PVC; Galv.; Other: ___

Quality
Water analysis obtained? (check) ☐ No ☐ Bacteriological ☐ Chemical

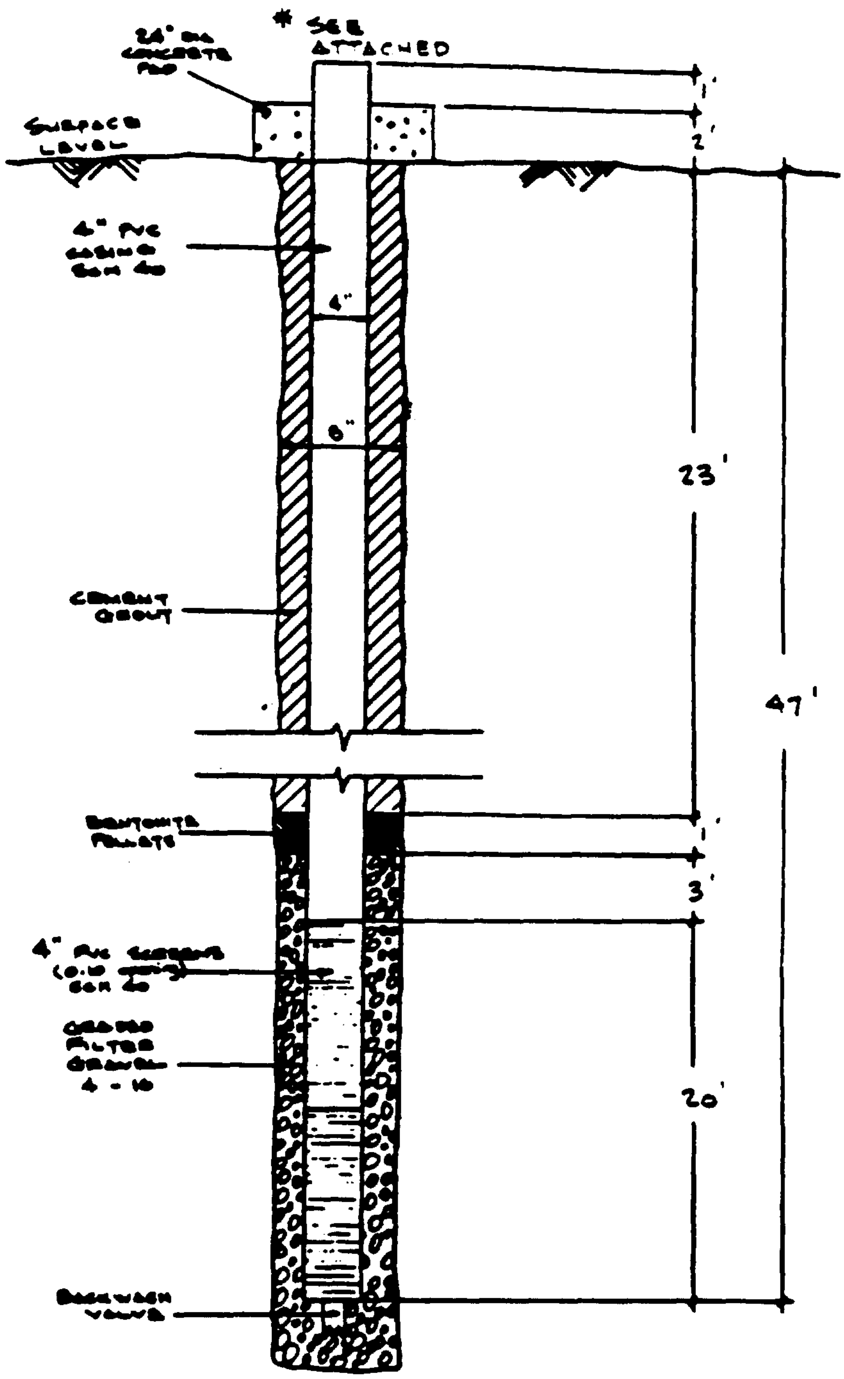
Analysis by: ☐ Ala Geol. Surv. ☐ U.S. Geol. Surv ☐ Ala Health Dept. ☐ Private lab.

Signed:

*For deeper well please attach continuation sheet.

ADEM Form 60 1/83

3 4 00252



Groves Well Drilling Co.
PROJECT OLIN CHEMICAL
WELL # — PL85
McINTOSH, AL

Drawn By 3P	Approved By MI	Date 2/26/85

NOTE — SUBMERSIBLE PUMP SET 40 FEET BELOW TOP OF PIPE.

NOT TO SCALE

REPORT OF DRILLED WELL

Drilling Company, Inc. P.O. Box 225, Sylacauga, Alabama 35150

R License Number Address Zip Code Date

apany, P.O. Box 28, McIntosh, Alabama 36553

ER Address (mailing) Zip Code

County 27 T3N R1E

ON County Section ¼ Section Township Range ---or:

3 4 00253

Distance and direction from nearest town, community, road junction or other reference point

WILL BE USED FOR: ☐ Private supply ☐ Public supply ☐ Industrial supply ☐ Test well

☐ Irrigation Other: Monitoring Well #PL-8-S

5 Drilling method: (check) Cable tool / Rotary X / Jetted / Bored Other: ______

4" Diameter of well 50' Estimated depth

SIGNATURE of Drilling Contractor

48'

Completion Date February 14, 1985

escription of cuttings	Inter-val	Description of cuttings
llow sand clay		
ed clay		
fine yellow sand		
m yellow sand and match head gravel		
clay		
Total Depth: 48'		
30' of PVC 4" pipe		
20' of PVC 4" Screen .010		
Air Test: 12 GPM @ 27-47'		
SL: 27'		

Completion data: report depths below ground level

Pump
Type: ☐ Turb. ☐ Subm. ☐ Jet ☐ Cyl.: Other: ______
Intake depth ______ H.P. ______ Yield ______ gpm

Capacity
Tested by: ☐ pumping ☐ air lift ☐ bailer ☐ none
Measured Static Water Level ______ ft.
Measured pumping level ______ ft. after ______ hrs. pumping ______ gpm
Development time prior to testing ______ hrs.

Finish
☐ Open hole ☐ Screened ☐ Slotted pipe ☐ Gravel pa.
Interval(s) screened: ______ to ______ ft. ______ to ______ ; ______ to ______ ft.
Packer(s) set at ______ and ______ ft.
Screen: diam. ______ ; Size openings ______

Casing

Interval cased	Diam. (inches)	*Type pipe	*Type couplings	Interval grouted

*Couplings: Threaded & Coupled (T&C) Welded (W) Threaded & coupled & welded (TC&W)

Other: ______

*Pipe: Black; PVC; Galv.; Other: ______

Quality
Water analysis obtained? (check) ☐ No ☐ Bacteriological ☐ Chemical

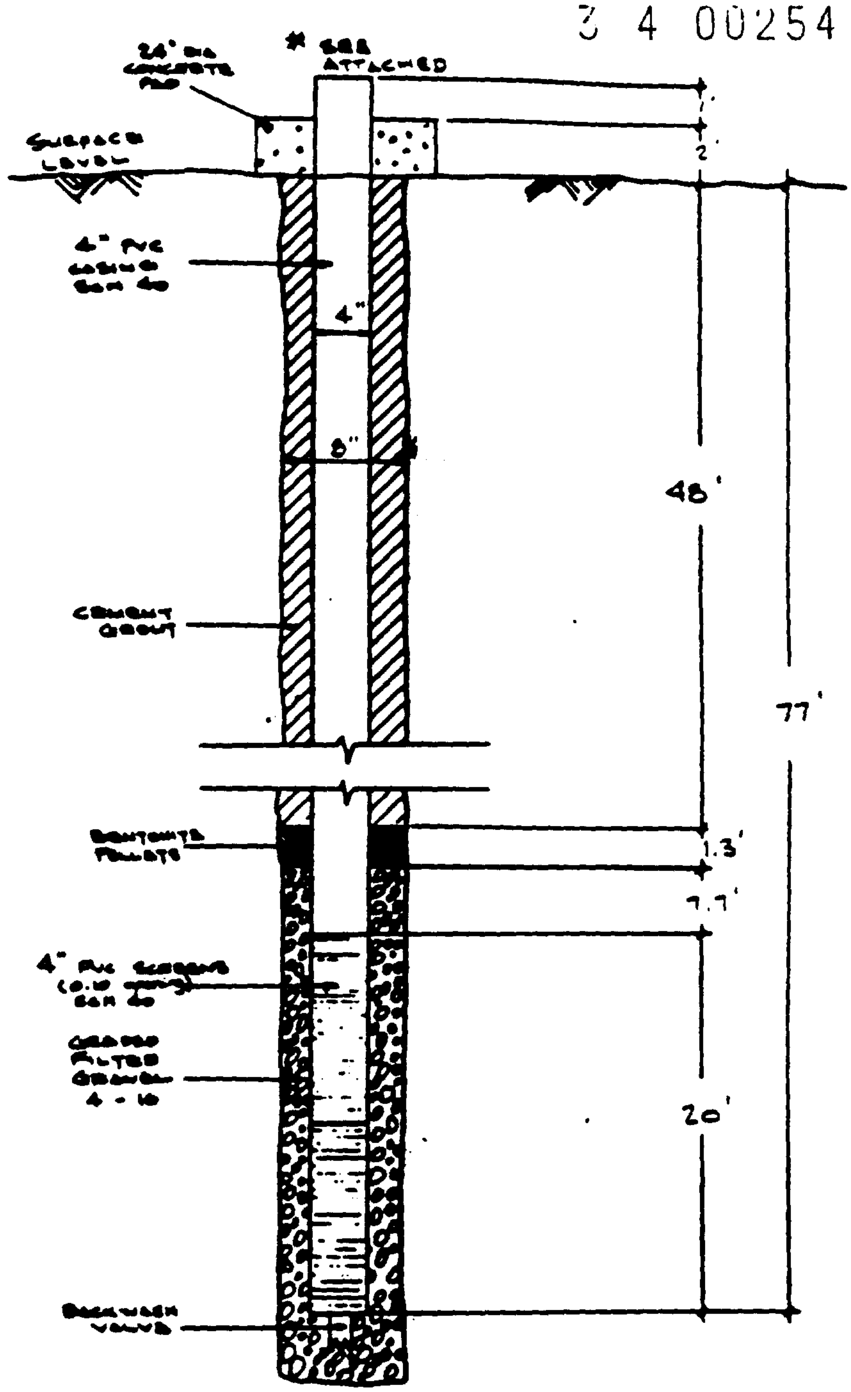
Analysis by: ☐ Ala Geol. Surv. ☐ U.S. Geol. Surv. ☐ Ala Health Dept. ☐ Private lab.

Signed: ______

*For deeper well please attach continuation sheet.

ADEM Form 60 1/83

3 4 00254



NOTE — SUBMERSIBLE PUMP SET 40' FEET BELOW TOP OF PIPE.

NOT TO SCALE

Graves Well Drilling Co.
PROJECT OLIN CHEMICAL
WELL # — PL 9D
McINTOSH, AL

Drawn by	Approved by	Date
SP	MD	2/26/85

REPORT OF DRILLED WELL

Graves Well Drilling Company, Inc. P.O. Box 225, Sylacauga, Alabama 35150

DRILLING CONTRACTOR License Number Address Zip Code Date

Olin Chemical Company, P.O. Box 28, McIntosh, Alabama 36553 3 4 002255

PROPERTY OWNER Address (mailing) Zip Code

Washington County S27 T3N R1E

WELL LOCATION County Section ¼ Section Township Range

Distance and direction from nearest town, community, road junction or other reference point

WELL WILL BE USED FOR: ☐ Private supply ☐ Public supply ☐ Industrial supply ☐ Test well ☐ Irrigation Other: Monitoring Well PL-9-D

2-18-85 Estimated starting date

Drilling method: (check) Cable tool, Rotary X, Jetted, Bored

Other: ____

4" Diameter of well

100' Estimated depth

SIGNATURE of Drilling Contractor

Total Depth 77½'

Completion Date February 18, 1985

Interval	Description of cuttings	Interval	Description of cuttings
0-1'	black ash		
1-25'	yellow - gray clay		
25-30'	fine white sand		
30-77'	coarse yellow sand & pea gravel		
77-77½'	gray clay		
	Total Depth: 77½'		
	60' of 4" PVC casing		
	20' of 4" PVC screens .010		
	Air Test: 50 GPM @ 57-77'		
	SL: 20.5'		

*For deeper well please attach continuation sheet.

Completion data: report depths below ground level

Pump

Type: ☐ Turb. ☐ Subm. ☐ Jet ☐ Cyl.; Other: ____

Intake depth ____ H.P. ____ Yield ____ gpm

Capacity

Tested by: ☐ pumping ☐ air lift ☐ bailer ☐ none

Measured Static Water Level ____ ft.

Measured pumping level ____ ft. after ____ hrs. pumping ____ gpm

Development time prior to testing ____ hrs.

Finish

☐ Open hole ☐ Screened ☐ Slotted pipe ☐ Gravel pa...

Interval(s) screened: ____ to ____ ft.; ____ to ____ : ____ to ____ ft.

Packer(s) set at ____ and ____ ft.

Screen: diam. ____ ; Size openings ____

Casing

Interval cased	Diam. (inches)	*Type pipe	*Type couplings	Interval grouted

*Couplings: Threaded & Coupled (T&C) Welded (W) Threaded & coupled & welded (TC&W)

Other: ____

*Pipe: Black; PVC; Galv.; Other: ____

Quality

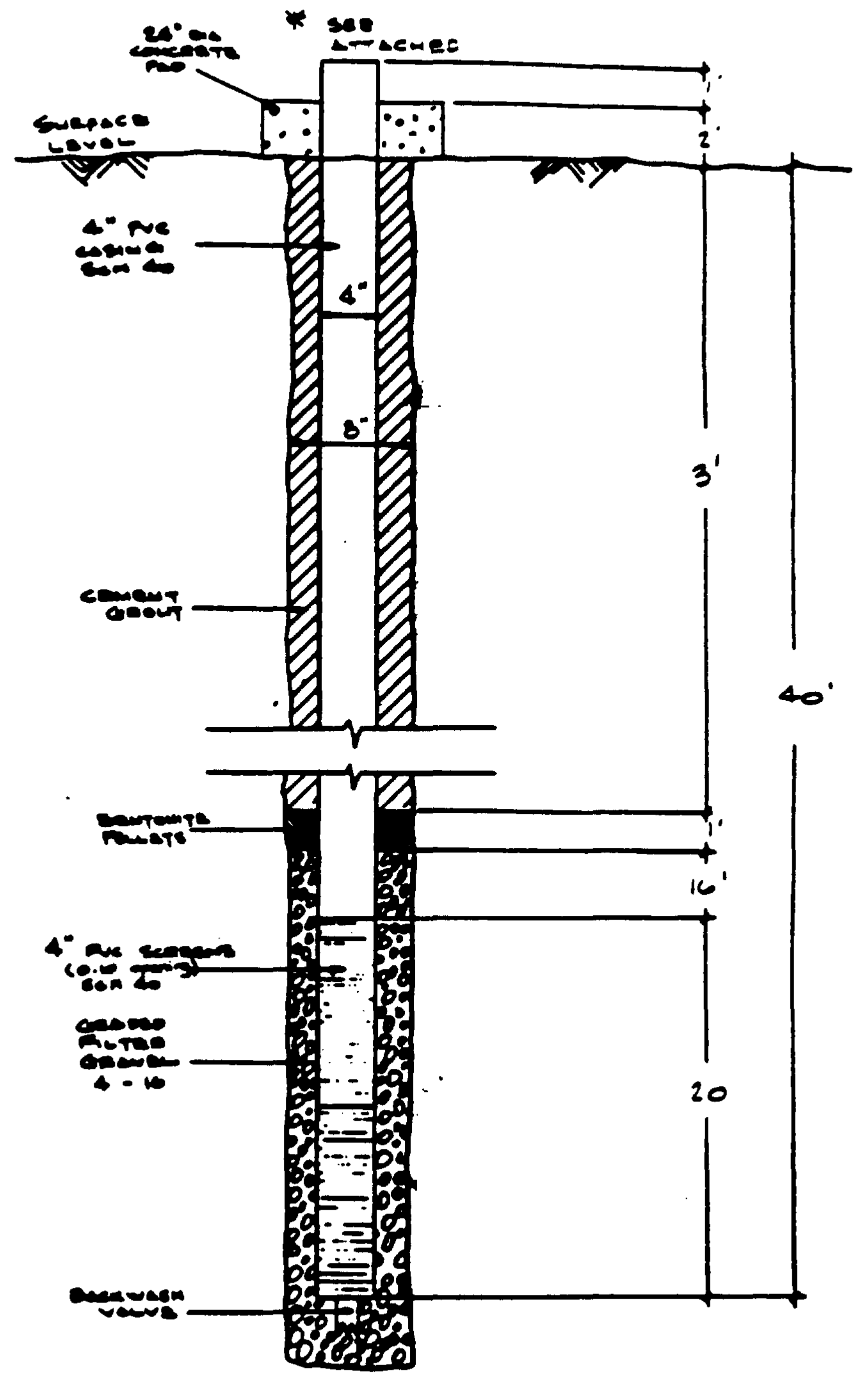
Water analysis obtained? (check) ☐ No ☐ Bacteriological ☐ Chemical

Analysis by: ☐ Ala. Geol. Surv. ☐ U.S. Geol. Surv. ☐ Ala. Health Dept. ☐ Private lab.

Signed:

ADEM Form 60 1/83

3 4 00256



NOTE — SUBMERSIBLE PUMP SET 40' FEET BELOW TOP OF PIPE.

NOT TO SCALE

Graves Well Drilling Co.
PROJECT OLIN CHEMICAL
WELL # — PL 95
McINTOSH, AL
BY SP | APPROVED BY ND | DATE 2/26/85

Graves Well Drilling Company, Inc. P.O. Box 225, Sylacauga, Ala. 35150 57

DRILLING CONTRACTOR — License Number — Address — Zip Code — Date

Olin Chemical Company, P.O. Box 28, McIntosh, Alabama 36553

PROPERTY OWNER — Address (mailing) — Zip Code

WELL LOCATION	County	Section	¼ Section	Township	Range
	Washington County	S27		T3N	R1E

Distance and direction from nearest town, community, road junction or other reference point

WELL WILL BE USED FOR: ☐ Private supply ☐ Public supply ☐ Industrial supply ☐ Test well ☐ Irrigation Other: Monitoring Well # PL-9-S

2-18-85 Estimated starting date

Drilling method: (check) Cable tool, Rotary X, Jetted, Bored, Other: ____

4" Diameter of well

50' Estimated depth

Mel Dolson

SIGNATURE of Drilling Contractor

Total Depth 40'

Completion Date February 18,1985

Interval	Description of cuttings	Interval	Description of cuttings
0-1'	black ash		
1-25'	yellow clay		
25-30'	fine white sand		
30-40'	coarse yellow sand & pea gravel		
40'	gray clay		
	Total Depth: 40'		
	23' of 4" PVC Casing		
	20' of 4" PVC screen .010		
	Air Test: 12GPM @ 20-40'		
	SL: 20.5'		

*For deeper well please attach continuation sheet.

Completion data: report depths below ground level

Pump: Type: ☐ Turb. ☐ Subm. ☐ Jet ☐ Cyl.: Other: ____ Intake depth ____ H.P. ____ Yield ____ gpm

Capacity: Tested by: ☐ pumping ☐ air lift ☐ bailer ☐ none. Measured Static Water Level ____ ft. Measured pumping level ____ ft. after ____ hrs. pumping ____ gpm. Development time prior to testing ____ hrs.

Finish: ☐ Open hole ☐ Screened ☐ Slotted pipe ☐ Gravel pa... Interval(s) screened: ____ to ____ ft ____ to ____ ; ____ to ____ ft. Packer(s) set at ____ and ____ ft. Screen: diam. ____ ; Size openings: ____

Casing:

Interval cased	Diam. (inches)	*Type pipe	*Type couplings	Interval grouted

*Couplings: Threaded & Coupled (T&C) Welded (W) Threaded & coupled & welded (TC&W)

Other: ____

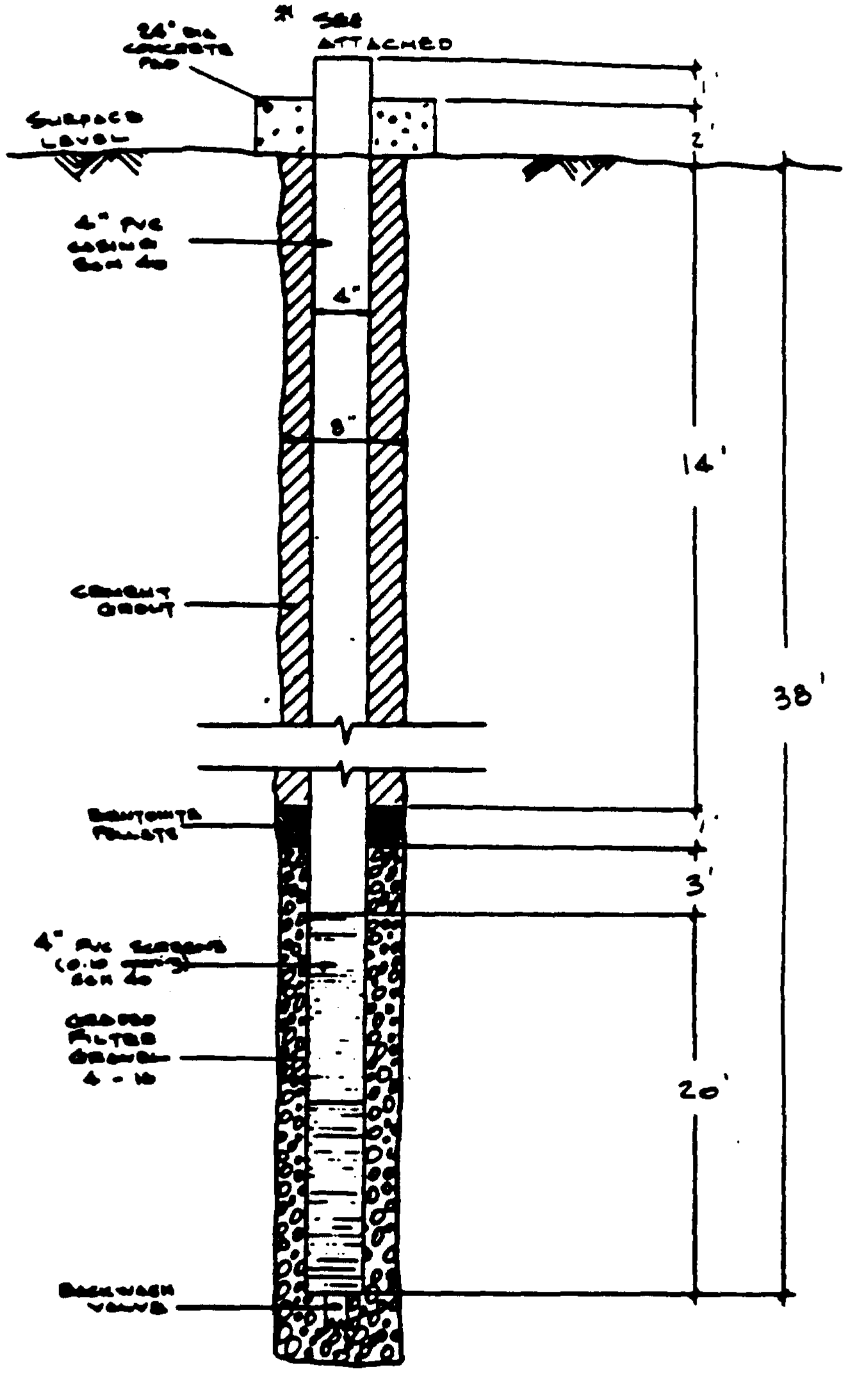
*Pipe: Black; PVC; Galv.; Other: ____

Quality: Water analysis obtained? (check) ☐ No ☐ Bacteriological ☐ Chemical

Analysis by: ☐ Ala Geol. Surv. ☐ U.S. Geol Surv. ☐ Ala Health Dept. ☐ Private lab.

Signed:

ADEM Form 60 1/83



NOTE — SUBMERSIBLE PUMP SET 38' FEET BELOW TOP OF PIPE.

NOT TO SCALE

Graves Well Drilling Co.
PROJECT OLIN CHEMICAL
WELL # — PL 10 S
McINTOSH, AL

DRAWN BY SP	APPROVED BY MD	DATE 2/26/85

Graves Well Drilling Company, Inc. P.O. Box 225, Sylacauga, Alabama 35150

DRILLING CONTRACTOR | License Number | Address | Zip Code | Date

Olin Chemical Company, P.O. Box 28, McIntosh, Alabama 36553

PROPERTY OWNER | Address (mailing) | Zip Code

Washington County | S27 | 7 | T3N | 4 | 002259 | R1E

WELL LOCATION | County | Section | ¼ Section | Township | Range ---or:

Distance and direction from nearest town, community, road junction or other reference point

WELL WILL BE USED FOR: ☐ Private supply ☐ Public supply ☐ Industrial supply ☐ Test well ☐ Irrigation Other: Monitoring Well # PL-10-S

2-15-85 Estimated starting date

Drilling method: (check) Cable tool, Rotary X, Jetted, Bored. Other:

4" Diameter of well

75' Estimated depth

SIGNATURE of Drilling Contractor

Total Depth 38'

Completion Date February 15, 1985

Interval	Description of cuttings	Interval	Description of cuttings
0-10'	yellow clay		
10-24'	yellow & gray clay		
24-35'	fine yellow sand		
35-38'	coarse sand and match head gravel		
38'	gray clay		
	Total Depth: 38'		
	21' of PVC 4" casing		
	20' of PVC 4" screen .010		
	Air Test: 20 GPM @ 18-38'		
	SL: 18'		

Completion data: report depths below ground level

Pump: Type: ☐ Turb. ☐ Subm. ☐ Jet ☐ Cyl.: Other: ______ Intake depth ______ H.P. ______ Yield ______ gpm

Capacity: Tested by: ☐ pumping ☐ air lift ☐ bailer ☐ none. Measured Static Water Level ______ ft. Measured pumping level ______ ft. after ______ hrs. pumping ______ gpm. Development time prior to testing ______ hrs.

Finish: ☐ Open hole ☐ Screened ☐ Slotted pipe ☐ Gravel pk. Interval(s) screened: ______ to ______ ft; ______ to ______ ; ______ to ______ ft. Packer(s) set at ______ and ______ ft. Screen: diam. ______ ; Size opening: ______

Casing:

Interval cased	Diam. (inches)	*Type pipe	*Type couplings	Interval grouted

*Couplings: Threaded & Coupled (T&C) Welded (W) Threaded & coupled & welded (TC&W)

Other: ______

*Pipe: Black; PVC; Galv.; Other: ______

Quality: Water analysis obtained? (check) ☐ No ☐ Bacteriological ☐ Chemical

Analysis by: ☐ Ala Geol. Surv. ☐ Ala Health Dept. ☐ U.S. Geol. Surv. ☐ Private lab

Signed:

*For deeper well please attach continuation sheet.

ADEM Form 60 1/83

VESTER J. THOMPSON, JR., INC.
ENGINEERS TESTING LABORATC :S
MOBILE, ALABAMA PASCAGOULA, MISSISSIPPI

3 4 00260

TEST BORING LOG

Olin Chimical

GROUND ELEVATION: ----

JECT: Groundwater Monitoring Wells

DATUM: Present Ground Surface

3 NO.: 3071-80-255-E

DATE DRILLED: 12/15/80

GR. WATER DEPTH: ----

RING NO.: B-99 WG-3

LOCATION: As Directed

TYPE BORING: ASTM D-1586

EPTH IN FEET	DESCRIPTION	NO.	BLOWS PER FT. NO	% W.C.	ATTERBERG LIMITS L. L.	P. I.
0	Very LOOSE gray SILTY SAND	1	2			
5	STIFF tan and gray SANDY SILTY CLAY	2	12			
10		3	13			
15	STIFF to Very STIFF gray and red SANDY CLAY	4	14			
20		5	17			
25		6	16			
30		7	17			
35	DENSE medium to coarse tan and white SAND with small amount of pea gravel	8	38			
40		9	47			
45		10	33			
50		11	34			
55		12	30			
60		13	33			
	B.T. @ 61.5'					
65						
70						

Graph scale: 5 10 20 30 40 50

VESTER J. THOMPSON, JR., INC.
MATERIALS AND SOILS MECHANICS LABORATORIES
3707 COTTAGE HILL ROAD – MOBILE, ALABAMA 36609

WE-3
3 4 00261

FIELD ENGINEER'S LOG

For: Olin Report No. ______
______ Our Order No. ______
Name of Project: ______ Sheet No. ______ of ______
Boring No. B-44 Field Engineer David Malecki Date 12-15-80
Ground Elev. ______ Datum ______ Gr. Water Elev. ______

Sample No.	Sample Depth—Feet From	Sample Depth—Feet To	Depth Stratum Feet From	Depth Stratum Feet To	Visual Classification	*Blows Per 6" 1st	*Blows Per 6" 2nd	*Blows Per 6" 3rd	
1.	[illegible]	1.5	0.0		Gray Silty Sand	1	1	1	2
2.	5.0	6.5	3.5	3.5	Tan Sand Clay - Med	2	5	7	12
3.	10.0	11.5	13.5	13.5	Silty Gray Sand Clay	3	6	7	13
[illegible]	[illegible]	[illegible]			[illegible]	6	8	[illegible]	14
5	[illegible]	[illegible]			[illegible]	7	8	9	17
6.	[illegible]	[illegible]			Hard Tan + Gray Silty Clay	7	9	7	16
7.	30.0	[illegible]	33.0	33.0	Hard Tan Silty Clay	[illegible]	7	[illegible]	17
8.	35.0	[illegible]			Med [illegible] Tan Sand	11	18	20	38
9.	40.0	41.5			Med + Coarse White Sand	24	25	22	47
10.	[illegible]	[illegible]			Coarse White Sand	12	14	19	33
11	[illegible]	[illegible]			" " " w/Fine Gravel	11	15	19	34
12.	[illegible]	[illegible]			" " " " "	18	14	16	30
13.	[illegible]	65		65	" " " " "	25	15	18	33

* Number of blows of 140 lb. hammer dropped 30 inches to drive 2 in. split-spoon sampler.

Remarks: ______

______ By ______
Field Engineer

I couldn't find WP-6
F.S

SOIL & MATERIAL ENGINEERS, INC.
SOIL BORING AND WELL RECORD

4 00262

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: WP-6A

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 6-29-82 Boring Depth: 80' Static Water Level:

Date Completed: 6-30-82 Well Depth: 80 Permeability Tests: Slug Test

Drilling Method: Rotary Casing: 2", 0-67.5 Chemical Analysis: EPS Labs

Development Method: Air surge Flush with fresh water

Soil Samples: Spl. Spn. Screen: 57.5 - 67.5

Geophysical Logs: G(S&ME) Grout and Seal: 0-30, 30-34

Depth Ft.	Elev. 52.27		Description	Penetration – Blows per ft (5 10 20 30 40 60 80)
			CLAY: Gray and brown mottled silty slightly micaceous fine slightly sandy plastic	
45			SAND: Brown fine to very coarse quartzose cherty sub-angular to sub-rounded with black minerals (organic odor)	
52			CLAY: Medium gray plastic fine to medium very sandy silty (organic odor)	
58			SAND: Gray very fine to very coarse quartzose sub-angular to sub-rounded with fine gravel silty some black minerals with 1.5 in clay lenses*	
			Gray very fine to very coarse quartzose sub-angular to sub-rounded very clayey with fine gravel (odor) and black minerals	
65			Very fine to fine with some medium quartzose sub-angular to sub-rounded slightly silty with black minerals	
73			CLAY: Blue-gray very plastic silty with a few lignite fragments	
80				
82			Total Depth: 82'	

*(organic odor)

3 4 00263

SOIL & MATERIAL ENGINEERS, INC.
SOIL BORING AND WELL RECORD

Location: ______ County: Washington Job No.: 071-077A Boring or Well No.: WP-9A

Logged by: L. Carter Drilled by: S&ME Grid Coord.: ______ Lat.-Long.: ______

Date Started: 7/7/82 Boring Depth: 48.5 Static Water Level: ______

Date Completed: 7/7/82 Well Depth: 48.5 Permeability Tests: ______

Drilling Method: Auger Boring Casing: 2", 0-43.5 Chemical Analysis: EPS Labs

Development Method: Air surface

Soil Samples: Cuttings Screen: 43.5 - 48.5

Geophysical Logs: ______ Grout and Seal: 0-36 , 36-40

Depth Ft.	Elev.		Description	Penetration — Blows per ft. 5 10 20 30 40 60 80
0–48.5			For boring log see WP-9 WP-9A 15' west of WP-9	
48.5			Total Depth: 48.5'	

SOIL & MATERIAL ENGINEERS, INC.

SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: WP-9

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 7-7-82 Boring Depth: 50' Static Water Level:

Date Completed: 7-7-82 Well Depth: 48.5 Permeability Tests:

Drilling Method: Auger Boring Casing: 2", 043.5 Chemical Analysis: EPS Labs

Development Method: Air surge

Soil Samples: Cuttings Screen: 43.5-48.5

Geophysical Logs: G(S&ME) Grout and Seal: 0-24, 24-28

Depth Ft.	Elev. 45.19		Description	Penetration – Blows per ft. 5 10 20 30 40 60 80
0–13			CLAY: Red-brown and gray silty fine slightly sandy plastic	
13–18			SAND: Orange very fine to fine with some medium quartzose sub-angular to sub-rounded slightly silty	
18–50			Tan and yellow very fine to medium quartzose sub-angular to subrounded	
50			Total Depth: 50' Auger Boring	

Depth scale: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65

OC-10000A REV 5/86

MAC

INTER OFFICE MEMO Olin

3 4 00265

TO A. L. Feldman AT Charleston DATE September 14, 1987

FROM M. J. Bellotti AT Charleston COPY TO J. C. Brown, W. H. Bridendall, S. G. Morrow, V. M. Norwood, T. B. Odom, D. R. Vaughn

SUBJECT McIntosh Corrective Action Wells - Flow Improvement Program

The following is a review of information re:

a) Borehole stratigraphy
b) Well screen packing gradation
c) Well recovery improvement after re-development

as required by your memo of August 14, 1987 (A. L. Feldman to W. H. Bridendall).

a) BOREHOLE STRATIGRAPHY

Boring logs for each of the CA well locations were compared to each other. CA-4 showed three differences in stratigraphic character from the other CA boreholes. The CA-4 log was then compared to logs for the three monitor wells nearest to it. The monitor well logs compared more closely to the CA-1, 2, and 5 logs and showed the same differences from the CA-4 log.

The three differences in stratigraphic character are:

1) There is a smaller percentage of the sand/gravel stratum in well CA-4. Well CA-4 has a 30 foot thickness of the sand and gravel stratum. All other wells noted above have between 40 and 50 feet of this stratum. Since this stratum is the coarsest in the soil column, it is a controlling factor in aquifer permeability. The relative coarseness of the other well locations suggests that the sediments at well CA-4 have a lower permeability than the sediments at the other well locations. Table 1 summarizes and compares the strata for each borehole.

2) The lowermost sand and sand/gravel strata are reversed in well CA-4. All boreholes except CA-4 exhibit a fining upward sequence of sediment size distribution, i.e., the lowermost sediments are sand/gravel strata and become finer toward the top of the soil column, grading to sand and clay. However at CA-4, the sand/gravel stratum and fine sand stratum are reversed, with the sand stratum lowermost in the soil column. This is a phenomenon of the environment of the sediments' deposition. This reversal also makes the cone of depression broader at its base, rendering inflow to the well more difficult.

3) Well CA-4 sits in a local depression in the Miocene clay aquitard which underlies the aquifer. While this depression is a factor in the differing environment of deposition noted above, it does not reduce well yield per se. Table 2 summarizes the differences in soil column thickness and in elevation of the Miocene clay surface. The added

thickness in the soil column at CA-4 is represented by less permeable sediments, and, hence does not add to the hydrologic productivity of that location. However, the location of CA-4 in this depression might assist in its collecting the contaminant plume, which settles to the base of the aquifer because of the density of its constituent chlorides.

Well logs are attached.

b) PACKING GRADATION

The packing gradation is primarily (60%) in the sand range, with 37% in the gravel range. Three percent is finer than fine sand (silt). The packing is relatively fine and is similar in gradation to the aquifer. The packing could restrict flow from the more productive flow locations, as found at CA-5, but is not likely to restrict flow from the finer strata, as found at CA-4. No seive analyses are available for each borehole location, so a quantitative comparison is not possible.

The packing gradation was selected by the drilling contractor.

The as-built packing gradation is summarized in Table 3, and in the attached gradation information provided by the drilling contractor. Table 4 shows a portion of the Wentworth scale of sedimentary particle sizes, from which the size descriptions are referenced.

c) WELL RECOVERY AFTER RE-DEVELOPMENT

Re-development of CA-5 improved well yield. ~~Well CA-5 shows the same recovery rate after re-development.~~ Field-measured well yield increased from 140 gpm to approximately 200 gpm.

Well CA-4 showed a similar recovery rate after re-development. Well yield stayed approximately the same (50 gpm). Re-development did not improve the yield of well CA-4. Further development at well CA-4 is not necessary.

Recovery curves are attached for recovery after pumpdown both before and after re-development of wells CA-4 and CA-5.

Michael J. Bellotti
Michael J. Bellotti

MJB/wsr
101/MJB4
Attachment

3 4 00267

TABLE 1 STRATIGRAPHIC SUMMARY

SEDIMENT TYPE	CA1	CA2	CA4	CA5	PL8D	PL9D	PL10D
				FOOTAGE			
clay	20	15	10	15	14	25	24
sand/ some clay	10	10	20	5	0	0	0
fine-med sand	30	15	35	30	26	5	11
sand/grav	40	40	30	40	43	47	45
tot depth to Miocene clay	100	80	98	88	83	77	80

TABLE 2 MIOCENE CLAY SURFACE ELEVATIONS AND SEDIMENT THICKNESS

BOREHOLE	MIOCENE CLAY ELEVATION ft-msl	SEDIMENT THICKNESS ABOVE MIOCENE CLAY ft
CA4	-60	98
CA5	-43	88
PL8D	-42	83
PL9D	-42	77
PL10D	-47	80

TABLE 3

AS-BUILT GRADATION as selected by the contractor

per cent	relative size fraction
37	coarser than coarse sand
60	between fine sand and coarse sand
3	finer than fine sand

TABLE 4 Size Breaks: Wentworth scale:

SEDIMENT TYPE	SIZE mm	SIZE in
gravel plus	2	0.078740
coarse sand	1	0.039370
fine sand	0.25	0.009842
silt	0.0625	0.002460
clay	0.0039	0.000153

GRINER DRILLING SERVICE, INC.

TELEPHONE 601/736-6347
POST OFFICE DRAWER 825
COLUMBIA, MISS. 39429

3 4 00268

FORMATION LOG FOR OLIN CORPORATION

ADDRESS P.O. BOX 28 MCINTOSH, ALABAMA

TEST HOLE NO. C.A.#1

TEST HOLE LOCATION Center of Sec 32 T4N R1E Washington County

FORMATION AND TEST HOLE INFORMATION

TOTAL DEPTH	THICKNESS EACH STRATUM	FORMATION	REMARKS
10	10	Clay	
15	5	Red Clay	
20	5	Clay with a little sand	
30	10	Sandy with some clay	
60	30	Fine to Medium Grain sand	
100	40	Sand and Pea Gravel	
103	3	Clay	

Date Started 6/5/87 19__ Date Completed 6/5/87

Jerry Beach Field Engineer

Gary Hill Driller

GRINER DRILLING SERVICE, INC.

TELEPHONE 601/736-6347
POST OFFICE DRAWER 825
COLUMBIA, MISS. 39429

3 4 00269

FORMATION LOG FOR Olin Corproation

ADDRESS P.O. Box 28 McIntosh, Al.

TEST HOLE NO. C.A. #2

TEST HOLE LOCATION SE Sec 31 T4N R1E Washington County

FORMATION AND TEST HOLE INFORMATION

TOTAL DEPTH	THICKNESS EACH STRATUM	FORMATION	REMARKS
5	5	Fill Clay	
15	10	Red Clay	
20	5	Clay and Sand	
25	5	Sand with Clay Streaks	
30	5	Sand with clay on Bottom	
40	10	Sand (Mediun and Fine)	
80	40	Sand with Pea Gravel	
83	3	Clay	

Date Started 6/11/87 19__ Date Completed 6/11/87

Jerry Beach Field Engineer

Gary hill Driller

GRINER DRILLING SERVICE, INC.

TELEPHONE 601/736-6347
POST OFFICE DRAWER 825
COLUMBIA, MISS. 39429

3 4 00270

FORMATION LOG FOR Olin Corporation

ADDRESS P.O. Box 28 McIntosh, Al

TEST HOLE NO. C.A. #4

TEST HOLE LOCATION SW of Sec 40 T4N R1E Washington Coun:

FORMATION AND TEST HOLE INFORMATION

TOTAL DEPTH	THICKNESS EACH STRATUM	FORMATION	REMARKS
5	5	Fill Clay	
15	10	Clay	
30	15	Sand (Fine to Medium)	
60	30	Sand and Pea Gravel	
70	10	Sand with Clay Streaks	
80	10	Sand	
90	10	Clay streaked Sand	
100	10	Sand and Clay with 2' of solid clay at bottom	

Date Started 6/2/87 19__ Date Completed 6/2/87

Jerry Beach Field Engineer

Gary hill Driller

GRINER DRILLING SERVICE, INC.

TELEPHONE 601/736-6347
POST OFFICE DRAWER 825
COLUMBIA, MISS. 39429

3 4 00271

FORMATION LOG FOR Olin Corporation

ADDRESS P.O. Box 28 McIntosh, Al

TEST HOLE NO. #5

TEST HOLE LOCATION SE of Sec 31 T4N R1E

FORMATION AND TEST HOLE INFORMATION

TOTAL DEPTH	THICKNESS EACH STRATUM	FORMATION	REMARKS
5	5	Top Soil and Clay	
10	5	Red Clay	
14	5	Red Clay with some sand	
20	5	Clay and Sand	
40	20	Sand	
60	20	Sand and small Pea Gravel	
80	20	Sand and Pea Gravel	
90	10	Sand with 2' Clay at Bottom	

Date Started 6/17/87 19__ Date Completed 6/17/87

Jerry Beach Field Engineer

Gary Hill Driller

3 4 00272 WP-6 (?)

SOIL & MATERIAL ENGINEERS, INC.
SOIL BORING AND WELL RECORD

Location: Olin McIntosh County: Washington Job No.: 071-077A Boring or Well No.: WP-

Logged by: L. Carter Drilled by: S&ME Grid Coord.: Lat.-Long.:

Date Started: 6-29-82 Boring Depth: 80' Static Water Level:

Date Completed: 6-30-82 Well Depth: 80 Permeability Tests: Slug Test

Drilling Method: Rotary Casing: 2", 0-67.5 Chemical Analysis: EPS Labs

Development Method: Air surge Flush with fresh water

Soil Samples: Spl. Spn. Screen: 57.5 - 67.5

Geophysical Logs: G(S&ME) Grout and Seal: 0-30, 30-34

Depth Ft.	Elev. 52.27	Description
		CLAY: Gray and brown mottled silty slightly micaceous fine slightly sandy plastic
45		SAND: Brown fine to very coarse quartzose cherty sub-angular to sub-rounded with black minerals (organic odor)
52		CLAY: Medium gray plastic fine to medium very sandy silty (organic odor)
58		SAND: Gray very fine to very coarse quartzose sub-angular to sub-rounded with fine gravel silty some black minerals with 1.5 in clay lenses*
		Gray very fine to very coarse quartzose sub-angular to sub-rounded very clayey with fine gravel (odor) and black minerals
65		Very fine to fine with some medium quartzose sub-angular to sub-rounded slightly silty with black minerals
73		CLAY: Blue-gray very plastic silty with a few lignite fragments
80		
82		Total Depth: 82'

*(organic odor)

McCarman

3 4 00273

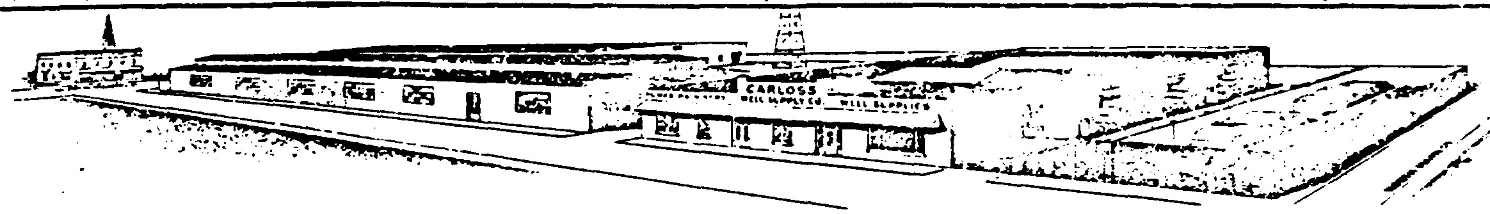
Handlers of water since 1880

BRANCH
1606 FIRST AVENUE NORTH
BIRMINGHAM, ALA. 35203
PHONE 324-0689

CARLOSS WELL SUPPLY CO.

111 NORTH PARKWAY
MEMPHIS, TENN. 38103
PHONE 526-1141

LARGEST AND MOST COMPLETE STOCK OF PUMPING EQUIPMENT AND WATER WELL SUPPLIES IN THE SOUTH



MEMPHIS, TENN.
November 1, 1972

#8 Water Well

Mr. Norman J. Brown
Olin Corporation
Nichols Works
Mc Intosh, Alabama 36553

Re: "NEW" Replacement Well No. 1

Dear Mr. Brown:

Please find enclosed our FINAL INVOICE (No. 4) in the amount of $500.00 (Our Inv. No. 2415-WC)

Also, we are enclosing in duplicate, the following data - - - - - - -

1. Drillers Lithological Log (Test Hole)
2. Dimensional Well Log
3. Carloss "Louver" Screen Sheet
4. Well Hydraulic Performance Test
5. Pump Performance Test

May we suggest that you compare the pump test with your characteristic pump performance curve in order to evaluate the well pump.

This is probably the finest well in this entire area and the best you can ever expect at your Mc Intosh facility. We're very proud of this one.

Please forward a copy of log to J. W. Fleming

PL

3 4 00274

Mr. Norman J. Brown
November 1, 1972
Page Two

It has again been our pleasure working with you and your fine people. We look forward to your next project with anticipation.

Yours truly,

CARLOSS WELL SUPPLY COMPANY

Orin Johnson
Vice President

OJ/dm
Encl.

RLOSS WELL SUPPLY CO.
Handlers of water since 1880

October - 1972

3 4 00275

Olin Corporation

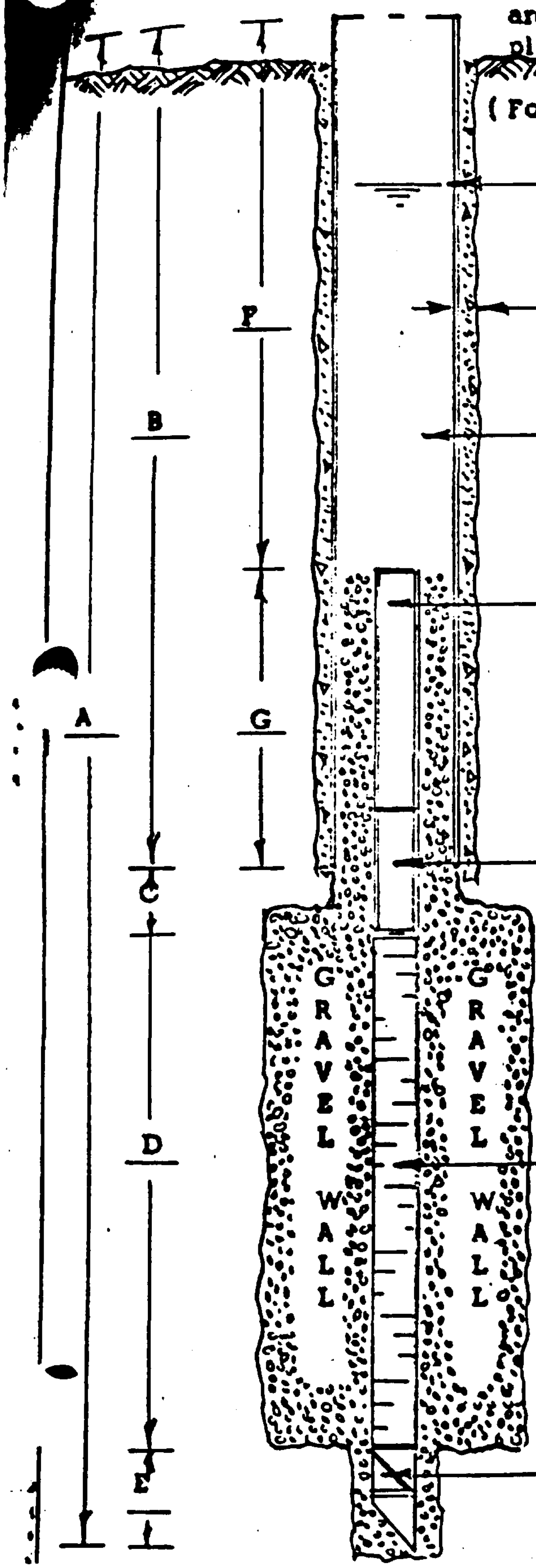
Nichols Works ~~County~~

McIntosh, Alabama

#8ww

All measurements are land surface plus 3'-6"

(Found, is L.S. + 1'-6")



90' Static Level
(19 Oct. 72)

2"
(24" Diameted Drilled Hole)

(Replacement)
Well #1
#1 - B

20" .375" Wall
78.60 lbs/ft. PE
Black Steel

12" .330" Wall
43.77 lbs/ft P.E.
Black Steel (12.75" OD)

"See Accompanying Formation Data Sheet "

12" .330" Wall "
43.77 lbs/ft P.E.
Black Steel

12" T-304
Stainless Screen
7 gauge

Underreamed From
205'-0" to 271'-0"

12" Back
Pressure Valve
& Set Nipple

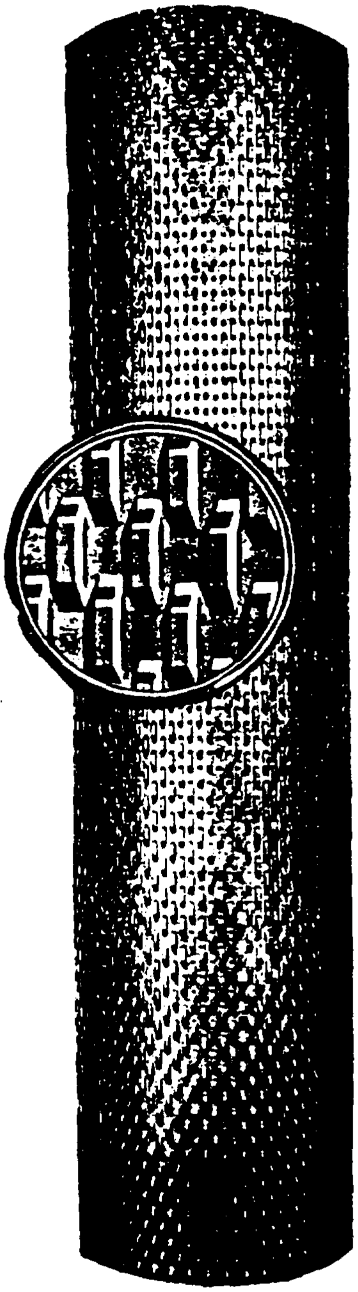
A.	272'-6"	F.	160'-0"
B.	202'-9"	G.	42'-9"
C.	7'-3"	S.	90'-0"
D.	60'-0"		
E.	2"-6"		

DC2A

CARLOSS GRAVEL WALL

3 4 00276

WATER WELL SCREEN



FEATURES

1. **MAXIMUM INLET AREA:**
2. **RUGGED CONSTRUCTION:**
3. **CORRECT MATERIALS TO WITHSTAND CORROSION:**
4. **PROPER DESIGN FOR *YOUR* FIELD CONDITIONS:**
5. **CAREFUL WORKMANSHIP:**

SLOTS ARE SCIENTIFICALLY PLACED IN THE VERTICAL POSITION, WHICH GREATLY MINIMIZES THE RESISTANCE TO PULLING OR REMOVING THE SCREEN AT A LATER DATE. THIS ALSO PERMITS UNIFORM LENGTH OF OPENINGS AND LESSENS POSSIBILITY OF CLOGGING.

OFF-SET OF THE OPENINGS (STAGGER) ARE ARRANGED IN A PATTERN WHICH ACTS AS A TRUSS OR BRACE ON THE WALLS OF THE SCREEN. THIS GIVES AN ADDED RESIST-ANCE TO CRUSHING FORCES.

OPENINGS ARE ON BOTH SIDES OF THE BRIDGING. THIS ENGINEERED AND DESIRED FEATURE ALLOWS A GREATER VOLUME TO FLOW THROUGH THE SCREEN WITH A RESULTING LOWER ENTRANCE VELOCITY.

SCREEN IS UNIFORMLY ROUND AND PERFECTLY SMOOTH ON THE INSIDE. ALL SECTIONS REST EXACTLY ON ONE ANOTHER WHICH ALLOWS A GREATER DOWNWARD STRESS.

SCREEN HAS A UNIFORM CIRCUMFERENCE THROUGHOUT AND IS THE SAME SIZE AS STANDARD STEEL PIPE AND CASING. THIS ALLOWS INTERJOINING AND EASY ADAPTION TO STANDARD PIPE AND WELL TOOLS.

14 GAGE
12 GAGE
10 GAGE

9 GAGE
8 GAGE
7 GAGE

CARLOSS WELL SUPPLY CO.
MEMPHIS, TENNESSEE

3 4 00277

CARLOSS WELL SUPPLY CO.

Handlers of water since 1880

Phone: 526-1141

109-115 North Parkway Ave.

MEMPHIS, TENN.

Req'n No. 530630

HYDRAULIC WELL AND PUMP TEST

Date 19 October 1972

Purchaser Olin Corporation Test Personnel Clarence Shelton

Location McIntosh, Alabama 36553

** Well No. 1 B Type Well Carloss "Underreamed" Gravel - Wall

Test No. Two (2) Motor No. J2-02259-967 Voltage 2300 (1800 RPM)

Pump No. ____ Type Pump Deming (Oil Lub.) w/8" Flg. Column

Size Well 20" x 12" Length Air Line 150' Static Water Level 90'

Orifice Size 10 " X 7 " Static A. L. Pressure 60'

Time	Disch. Lbs.	Press. Feet	Orifice Inches	U. S. G.P.M.	Alt. Ft. Left	DRAWDOWN	Pumping Level	Specific Capacity
STARTED PUMP @ 0900 -				60'	STATIC LEVEL			
1000	84	194'		1251	49	11	101'	113.73
1030	84	194'		1251	48	12	102'	104.25
1100	80	185'		1251	48	12	102'	104.25
1130	80	185'		1251	47	13	103'	96.23
1300	80	185'		1266	44	16	106'	79.13
1400	80	185'		1266	44	16	106'	79.13
1500	80	185'		1266	44	16	106'	79.13
1600	80	185'		1266	44	16	106'	79.13
1800	80	185'		1266	44	16	106'	79.13

Test Approved By ____

* AMPS - - - 34

** Replacing original Well No. 1

CARLOSS WELL SUPPLY CO.

By ____

CARLOSS WELL SUPPLY CO. 3 4 00278

Handlers of water since 1880

Phone: 526-1141

109-115 North Parkway Ave.

MEMPHIS, TENN.

Req'n No. 530630

HYDRAULIC WELL AND PUMP TEST

Date 19 October 1972

Purchaser Olin Corporation Test Personnel Clarence Shelton

Location Mc Intosh, Alabama 36553

* Well No. 1 - B Type Well Carloss "Underreamed" Gravel Wall

Test No. Two (2) Motor No. J2-02259-967 Voltage 2300 (1800 RPM)

Pump No. ______ Type Pump Deming (Oil Lub.) w/8" Flg. Column

Size Well 20" x 12" Length Air Line 150' Static Water Level 90'

Orifice Size 10 " X 7 " Static A. L. Pressure 60'

Time	Disch. Lbs.	Press. Feet	Orifice Inches	U. S. G.P.M.	Alt. Ft. Left	DRAWDOWN	Pumping Level	Specific Capacity
	90	208		1218	46	14	104	87.00
	80	185		1266	44	16	106	79.13
	70	162		1319	42	18	108	73.28
	60	139		1349	41	19	109	71.00
	50	116		1387	41	19	109	73.00
	40	93		1431	40	20	110	71.55
	30	69		1491	40	20	110	74.55
	20	46		1548	39	21	111	73.71
	0	OFF THE 10" x 7" CHART						

Test Approved By ______________

* Replacing original Well No. 1

CARLOSS WELL SUPPLY CO.

By ______________

3 4 00279

#8 WATER WELL

FORMATION LOG FOR OLIN CORPORATION

TEST HOLE NO. ADDRESS Mc Intosh ( ) Alabama

TEST HOLE LOCATION In the vicinity of old well no. 1 (which will be abandoned)

FORMATION AND TEST HOLE INFORMATION

TOTAL DEPTH	THICKNESS EACH STRATUM	FORMATION	REMARKS
5'	5'	Top Soil - - - - - "Fill"	
19'	14'	Hard Blue Clay	
62'	43'	Coarse Sand & Pea Gravel	
85'	23'	Sand & Pea Gravel w/ Streaks of Clay	
123'	38'	Hard Clay	
184'	61'	Hard Clay w/ Streaks of Sand	
190'	6'	Sandy Clay	
270'	80'	Sand w/very small Gravel	
276'	6'	Fine Silty, Soft sand cut loose	
317'	41'	Sand w/ small gravel	
340'	23'	Clay w/thin streaks sand	
		*Stopped test drilling at 340'	
		(measurements are surface plus 3'-6")	
		* Laboratory results indicate most productive	
		zone from 200' to 270'	

DATE STARTED 7 Sept. 19 72 DATE COMPLETED 8 Sept. 19 72

Orin Johnson FIELD ENGINEER

APPENDIX C

RESUMES OF PROJECT PERSONNEL

Woodward-Clyde Consultants
3 4 00281

DHAMO S. DHAMOTHARAN

waste management
hydrogeology and hydrology
water resources
computer applications and modeling
civil and environmental engineering
project management

EDUCATION

University of Minnesota: Ph.D., Civil Engineering/Hydrology and Hydrogeology.

University of Madras: M. S., Civil Engineering/Water Resources.

University of Madras: B. S., Civil Engineering

REGISTRATION

Professional Engineer:
Idaho, Alabama, Mississippi, Louisiana, Texas, Arkansas and Florida

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Vice President and Managing Principal, 1989 - Present.

Woodward-Clyde Consultants, Vice President, Earth Sciences and Waste Management, October 1984 - December 1988.

Morrison-Knudsen Co., Boise, Idaho, Manager, Hydrologic Analysis, June 1981 -September 1984.

Morrison-Knudsen Co., Boise, Idaho, Senior Hydrologist, April 1980 - June 1981.

University of Minnesota, Minneapolis, Minnesota, Department of Civil and Mineral Engineering, Research Faculty, December 1978 - April 1980.

University of Minnesota, Minneapolis, Minnesota, St. Anthony Falls Hydraulic Laboratory, Research Assistant, September 1974 - December 1978.

Public Works Department, Government of Madras, Design Engineer, May 1971 - September 1974.

Public Works Department, Government of Madras, Water Resources Engineer, May 1969 - May 1971.

Government Polytechnic, Trichy, Senior Instructor in Civil Engineering, July 1968 - May 1969.

REPRESENTATIVE EXPERIENCE

Dr. Dhamo S. Dhamotharan, Vice President and Managing Principal of Woodward-Clyde Consultant's Baton Rouge Operating Unit, has been actively engaged in the field of waste management, water resources, hydrogeology and hydrology for the past 20 years. Other areas of his direct experience are remedial actions design for hazardous waste sites, environmental permitting, ground-water pollution, waste isolation and management, aquifer characterization, dewatering design, mine water control, river engineering, sedimentation, computer application, mathematical modeling, and project management.

Dr. Dhamotharan has a great deal of experience in waste management and water resources. He has worked both in private and public sector agencies. He is a registered professional engineer in all of the Gulf States and is very familiar with the state and federal regulations in the waste management area.

Currently, Dr. Dhamotharan is acting as Project Director for several large waste management projects in the Gulf States area. He has participated in a number of public meetings which have involved presenting technical information on behalf of the industrial clients to the public on complex waste management projects and answering relevant questions. Dr. Dhamotharan also interacts very closely with legal counsel and law firms representing industrial clients on strategy development in presenting facts and figures to the public, regulatory agencies and for expert testimony. He has a very strong professional relationship with regulatory agencies at the state and federal level.

With Woodward-Clyde, Dr. Dhamotharan has conducted several projects involving environmental permitting, aquifer characterization, designing and installation of ground water monitoring system, characterization of hazardous waste sites, design of remedial measures for contaminated sites, design of surface water control system for large hazardous waste sites for industrial clients. He is the Office Director with over all responsibility for the technical supervision and office management. The office consists of four departments: Earth Sciences, Environmental Engineering, Geotechnical Engineering and Material Science and Field Services. He has been heavily involved in the preparation of Part II Permit Application meeting the U. S. EPA and Hazardous Waste Regulations for various chemical plants and petroleum refineries. He was also the Project Manager for a study done for Calcasieu Parish to appeal FEMA's flood insurance study. Dr. Dhamotharan is very familiar with RCRA, CERCLA, SARA and other federal and state environmental regulations. Typical example projects for which Dr. Dhamotharan has been or currently is project manager and actively associated with are as follows:

- Project Manager for design and implementation of a closure plan for a hazardous waste dump in northern Louisiana under RCRA
- Site Manager for REM II Superfund site for RI/FS in Mississippi
- Project Manager for several hazardous waste and solid waste permit application preparations at several places in Louisiana
- Project Manager for a landfarm feasibility study
- Project Manager for several projects requiring detailed response to compliance orders from the regulatory agencies on behalf of several industrial clients in U. S. EPA Regions IV and VI
- Project Manager for design, implementation and execution of a hazardous waste site closure involving EDC
- Project Manager for planning and preparing risk assessment model involving hazardous waste contamination of ground water
- Review of surface water control designs for hazardous waste landfill in Texas
- Review of closure plans for wood treatment facility
- Site Manager for ground water contamination characterization study for a petroleum refinery
- Project Manager for oil field waste site subsurface characterization and brine pond restoration

While at Morrison-Knudsen, Dr. Dhamotharan served as the Project Manager for a petroleum refinery hazardous waste project in New Mexico. In this project, he was responsible for identifying the sources of environmental and ground-water pollution in the plant area and suggesting necessary remedial actions complying with EPA. Along with this, he was also involved with a large hazardous waste project for a confidential client. He has supervised more than ten professional engineers/geologists working in the areas of hydrology, hydrogeology, waste management and computer modeling.

Dr. Dhamotharan directed a large mine dewatering/depressurization project for a lignite mine near Carlos, Texas. This involved a thorough characterization of the ground-water regime of the area by intensive six-month field investigation, monitoring well design and installation, geophysical logging, aquifer testing and data analysis followed by a design and implementation of a dewatering/depressurization system. The system has proven to be very successful. Other projects while at Morrison-Knudsen included contaminant transport modeling, surface water and ground water modeling, hydrological and hydrogeological baseline studies, environmental engineering and permitting, mine water control and reclamation. Project sites were located in Wyoming, Texas, Idaho, Oregon, Washington, Utah, Colorado, New Mexico, Columbia South America, and Canada.

Dr. Dhamotharan is conversant with SCS-TR 20, HEC 1, HEC 2, RESQUAL and other similar models in surface water hydrology; PLASM, RANDOM WALK AQUIFEM, and SUTRA models in hydrogeology; and has developed and/or modified computer models for specific projects and site conditions.

As a member of the Research Faculty at the University of Minnesota, Dr. Dhamotharan has conducted several applied research projects in the area of thermal pollution, reservoir hydrodynamics, river engineering, sedimentation and computer modeling. He has also taught course in fluid mechanics, hydraulics and water resources. He has been actively engaged in the Mississippi River sedimentation, navigation and water quality studies in Minnesota. He had developed a mathematical model "RESQUAL" for the prediction of temperature and water quality dynamics in reservoirs. This project was funded by Vicksburg District Corps of Engineers and USDA Sedimentation Laboratory at Oxford, Mississippi. Dr. Dhamotharan has done extensive field work in Mississippi and Arkansas relating to water quality aspects. One of the projects funded by EPA and co-directed by Dr. Dhamotharan involved study of the mechanics of bedload transport in gravel streams and its effect on aquatic life.

During his assignment with the Government of Madras, Dr. Dhamotharan was heavily involved in the surface water hydrology, design and execution of small and medium size dams, and hydraulic structures. This included economic analysis of projects and coordination with local public and other governmental agencies. He was also involved in the design and execution of a large multi-purpose water resources project. This included flood control, hydropower, irrigation, and construction management.

During his tenure at the Polytechnic, Dr. Dhamotharan taught courses in surface water hydrology, sanitary engineering and hydraulics. He was responsible for setting up the Hydraulics/Water Resources Laboratory for the institute.

AWARDS

Alvin G. Anderson Award, University of Minnesota, 1976, for academic achievement.
Fellowship by the U. S. Department of Agriculture, 1976 - 1978.
Service Award by American Water Resources Association, 1985.
Listed in Who's Who in West.

AFFILIATIONS

General Secretary, American Water Resources Association (1986-1988)
Editor, HYDATA, Publication of American Water Resources Association (1982-1985)
American Society of Civil Engineers
American Society of Mining Engineers
Chi Epsilon, Sigma-Xi

PUBLICATIONS

"Maintenance and Regulation of Navigable Channels by the Use of Submerged Contractions" (with W. Q. Dahlin and J. M. Wetzel), paper presented at 2nd International Symposium on Dredging Technology, BHRA Fluid Engineering and Texas A & M University, November 1977.

"Measurements and Model Simulation of Stratification Dynamics of Lake Chicot, Arkansas" (with H. G. Stefan and F. R. Schiebe), paper presented at the 41st Annual Meeting of the American Society of Limnology and Oceanography, Inc., held at Victoria, British Columbia, June 1978.

"Mathematical Simulation Compared to Measurements of Stratification Characteristics of a Large and Turbid Oxbow Lake" (with H. G. Stefan and F. R. Schiebe), paper presented at the ASCE Hydraulic Division Specialty Conference at University of Maryland, August 1978.

"Prediction of Post Construction Turbidity of Lake Chicot, Arkansas" (with H. G. Stefan and F. R. Schiebe), paper presented at the IAHR International Symposium on Environmental Effects of Hydraulic Engineering Works, TVA, September 1978.

"Cooling Water Intake Manifold (Header) Study for the James H. Campbell Electric Power Generating Plant, Unit No. 3" (with H. G. Stefan and C. Shanmugam), St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Project Report No. 178, January 1979.

"Stratification and Water Quality Prediction in Shallow Lakes and Reservoirs" (with H. G. Stefan, D. E. Ford and M. Hanson). Proceedings of IAHR Second International Symposium on Stratified Flows, 1980.

"Model Studies of a Cooling Water Discharge Modification - Monticello Nuclear Generating Plant" (with J. Wetzel and W. Q. Dahlin), St. Anthony Falls Hydraulic Laboratory, Project No. 192, April 1980.

"Mathematical Model for Temperature and Turbidity Stratification Dynamics in Shallow Reservoirs" (with H. G. Stefan). Paper presented at the ASCE Symposium on "Surface Water Impoundments," Minneapolis, Minnesota, June 1980.

"Mechanics of Bedload Transport in Gravel Streams," Proceedings of 19th International Association for Hydraulic Research Congress, New Delhi, India, February 1981.

"Unsteady One-Dimensional Settling of Suspended Sediment" (with J. Gulliver and H. G. Stefan). Water Resources Research, August 1981.

"Modeling of Sediment Transport - A Basic Approach" (with C. S. Song and A. O. Wood). Paper presented at ASCE Water Forum, California, August 1981.

"Aquifer Protection Regulations and Policies" (with Steve Allred and Roger Henning). Paper presented by invitation at ASCE, Spring Convention, Las Vegas, Nevada, April 1982.

"Run Off Curve Number Estimation Using Remote Sensing Techniques" (with Kim Johnson and Steve Allred). Paper presented at AWRA International Symposium on Hydrometeorology, Denver, Colorado, June 1982.

"Mathematical Modeling of Lake Chicot, Arkansas, Water Quality" (with H. G. Stefan and F. R. Schiebe). Paper presented at the Lake Management Conference, Arkadelphia, Arkansas, October 1983.

"Systems Design for the Use of Monitoring Data for Other Than Regulatory Purposes" (with Roger Henning and Steve Allred). Invited paper for the National Water Well Association Conference, Denver, Colorado, July 1982.

"Temperature/Sediment Model for a Shallow Lake" (with H. G. Stefan and F. R. Schiebe). Journal of Environmental Engineering Division, ASCE, August 1982.

"The Design and Implementation of a Dewatering/Depressuring System for an Open-pit Lignite Mine in S. E. Texas." Paper presented at NWWA Conference in Denver, Colorado, August 1984.

"Application of Ground Water Models to Microcomputers" (with Roger Henning). Invited paper presented at ASCE Spring Convention, Denver, Colorado, April 1985.

"A Case Study of a Dewatering/Depressuring System" (with Rod Cezeaux). Invited paper presented at Texas Lignite Conference, Houston, Texas, November 1984.

"Environmental Considerations for Water Resources Projects" (with V. Singh). Invited paper presented at the International Conference in Rourkee, India, December 1985.

"Case Study of a Risk Assessment Model Using Micro Computers" (with Tissa). Paper presented at ASCE Conference at Boston, Massachusetts, October 1986.

"Role of Solute Transport and Geochemical Models in Alternate Concentration Limits Demonstration" (with B. V. Rao). Presented at the HazMacon Conference in Santa Clara, California, April 1989.

Woodward-Clyde Consultants

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WILLIAM A. BEAL

geology
ground water remediation
ground water hydrology
contaminant hydrogeology
ground water monitoring
engineering geology

EDUCATION

University of North Dakota, M.S., Geology; 1986
University of North Dakota, B.S., Geological Engineering; 1983

REGISTRATION

Registered Geologist, Arkansas

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Project Geologist, 1990 - present.

Westinghouse Environmental and Geotechnical Services, Ground Water Remediation and Site Assessment Manager, 1988 - 1990.

IT Corporation, Project Hydrogeologist, 1985 - 1988.

North Dakota Mining and Mineral Resources Research Institute, Research Assistant, 1983 - 1985.

REPRESENTATIVE EXPERIENCE

Mr. Beal has over seven years experience in ground water quality assessments and remedial actions at RCRA and CERCLA sites. His experience includes numerous ground water remediation and contaminant hydrogeology projects in the Gulf Coast:

- o Project Hydrogeologist at a VCM plant in southern Louisiana; activities included development of a Ground Water Quality Assessment and design of a pilot ground water recovery program in an area contaminated with chlorinated hydrocarbons.

- Project Hydrogeologist at a chemical plant in southern Louisiana. Site has been contaminated with dense non-aqueous phase chlorinated hydrocarbons in three permeable zones to a depth of 100 feet. Responsible for installation of the recovery wells, and support of client with design and installation of a recovery system to optimize phase recovery.

- Installed a multi-well ground water extraction system to recovery PCB-contaminated ground water at an industrial facility in southern Louisiana.

- Worked on major projects involving creosote contamination, specifically, assessing the nature and extent of contamination, and estimating migration rates for both aqueous and non-aqueous phase liquids.

- Conducted investigations, assessments and remedial actions at sites contaminated from leaking underground storage tanks.

- Conducted a ground water investigation at a site in Arkansas contaminated with volatile organics; activities included installation of monitor wells, assessment of the extent of contamination and development of remedial alternatives.

- Provided continuous support to local industrial clients on their ongoing RCRA ground water protection activities (detection, assessment and corrective action programs).

- Developed ground water monitoring plans for hazardous waste facilities including a proposed 350,000 ton per year commercial facility in Louisiana.

While at Westinghouse, Mr. Beal managed the Ground Water Remediation Department. This department handled bidding and managing projects involved with installation of ground water recovery systems, and fabrication and installation of the associated water treatment systems. Typical projects include:

- Installation operation and demobilization of a Pilot Recovery and Treatment System at the Bayou Bonfouca Superfund Site in Slidell, Louisiana.

- Installation of a system to recover and treat ground water contaminated with Freon 113 at the Johnson Space Center in Houston, Texas.

PROFESSIONAL AFFILIATION

Association of Ground Water Scientists and Engineers
Baton Rouge Geological Society
Sigma Gamma Epsilon

PUBLICATIONS

Beal, W. A., Murphy, E. C., and Kehew, A. E., 1987, Migration of Contaminants from Buried Oil-and-Gas Drilling Fluids within the Glacial Sediments of North-Central North Dakota: North Dakota geological Survey Report of Investigation No. 86, 43 p.

Murphy, E. C., Beal, W. A., and Kehew, A. E., 1986, The Effects of Buried Drilling Fluids on Shallow Ground Water in North Dakota: National Conference on Drilling Muds, Norman Oklahoma, May 29-30, 1986, conference Proceedings, pp. 212-243.

Murphy, E. C., Kehew, A. E., Groenewold, G. H., and Beal, W. A., 1985, Investigation of a surface brine flow from an abandoned seismic shot hole in the Black Slough Oil Field, Burke County, North Dakota in Characterization of detrimental effects of salts and other chemical constituents carried in surface and subsurface waters from brine and drilling fluid disposal pits buried during oil development: North Dakota Water Resources Research Institute, 238 p.

Murphy, E. C., Kehew, A. E., Groenewold, G. H., and Beal, W. A., 1988, Leachate generated by an oil-and-gas brine pond site in North Dakota: Ground Water, Vol. 26, No. 1, p. 31-38.

DOUGLAS R. HAHN

fisheries/aquatic biology
environmental audits
water resources
solid waste management
special waste management
hazardous waste management

EDUCATION

University of North Dakota, Ph.D., Biology, 1974
Iowa State University, NDEA Fellow, 1973-1974
University of North Dakota, M.S., Biology, 1972
University of North Dakota, B.S., Fisheries and Wildlife Management, 1970
Wartburg College, 1966-1968

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Project Scientist and Group Manager, 1989 - present.
Sedgwick County Department of Environmental Resources, Wichita, Kansas, Director, 1980 - 1989.
Wichita State University, Adjunct Professor of Biology, 1980 - 1989.
Camp Dresser & McKee, Inc., Senior Biologist, 1977 - 1980.
Doane College, Assistant Professor of Biology, Division of Natural Sciences, 1974 - 1977.
University of North Dakota Medical School, Pathology Department, 1974.
University of North Dakota, Graduate Teaching Assistant, 1974.
University of North Dakota, Graduate Research Assistant, 1973.
Lake Andes National Wildlife Refuge, Biological Aide, 1969.

REPRESENTATIVE EXPERIENCE

Dr. Hahn, Senior Project Scientist and Group Manager, has over 21 years of experience in the environmental science field. His direct experience includes work in fisheries biology, aquatic biology, field ecology, water resources, environmental auditing, site assessment, environmental impact analysis, management of solid, special, and hazardous wastes, lake restoration, sewage treatment systems, land use, environmental education, environmental baseline studies of uranium solution mining, electric utility site assessments, college teaching in the environmental field, and project management.

Since his employment with Woodward-Clyde Consultants, Dr. Hahn has served as a Senior Project Scientist, as a Group Manager, as a Project Manager, and is developing new areas within Woodward-Clyde related to his experience. Dr. Hahn served as Woodward-Clyde's Louisiana Project Manager for a series of projects (16 sites in Louisiana and several locations in Mississippi) associated with a major gas pipeline company's compressor stations and sites. Some of the latter activities include biological assessments of potential contaminants in aquatic systems. The primary contaminant in this work was polychlorinated biphenyl (PCB) although some HSL compounds were also implicated.

Dr. Hahn's work with Woodward-Clyde has included several studies for confidential clients involving persistent chemicals in aquatic ecosystems. Two studies involved the characterization of the presence of PCBs in two Louisiana lakes and included analysis of alternatives for dealing with the fish, water, and sediments in those two situations. Another study involved the analysis of 10 years of fisheries data for a river ecosystem in northern Alabama which had been remediated for DDT presence. Another study included the development and implementation of a scope of work for aquatic biota sampling (fish and benthos) as a portion of an RI/FS for mercury presence in a basin in southwestern Alabama. Five studies involved the characterization of the presence of PCBs in fish in a large reservoir, two rivers, and two streams in Kentucky for a single client. All of the aforementioned studies involved numerous presentations to and negotiations with various state and federal environmental agencies.

Prior to his employment with Woodward-Clyde, Dr. Hahn served as Director of the Department of Environmental Resources in Sedgwick County, Kansas, a non-regulatory agency in the most populous county in the state. In that capacity, Dr. Hahn was responsible for planning, supervising, and coordinating the activities, budget, and personnel of the agency including interfacing with the public, the Board of County Commissioners, city and county officials, and other local, state, and federal agencies regarding environmental issues facing Sedgwick County and its citizenry. Major activities included providing technical advice to local and state elected officials on a variety of environmental matters; preparing an inventory of environmental data for the county; studying the feasibility of resource recovery from solid wastes generated in Sedgwick County including the City of Wichita; developing a computerized environmental library for research and public use; studying and evaluating specific environmental issues within the county such as hazardous wastes, solid wastes, air quality, local lake restoration, sewage treatment systems, water supply and quality, fish and wildlife resources, and land use; working with local business, industry, and development interests to seek cost-effective and environmentally compatible solutions to problems; conducting environmental audits for local businesses and industries; and developing a public awareness and public education program related to environmental matters including teaching several graduate courses and workshops, presentations to schools and public groups, developing nature trails, and developing educational materials. Dr. Hahn served on numerous local and state committees and task forces dealing primarily with water resources and waste management issues.

Dr. Hahn spent 9 $^{1}/_{2}$ years working extensively on solid waste management problems in the State of Kansas. His specific experience included dealing with solid waste management regulations (federal, state, and local including the proposed subtitle D landfill regulations), drafting solid waste legislation including flow control, testimony before the Kansas legislature regarding needed solid waste legislation and successful lobbying for the passage of same, conducting feasibility studies and financial analyses (including computer modeling of spreadsheet alternatives) of solid waste management alternatives, developing solid waste management plans, sampling local solid waste streams to establish quantitative and composition data on the same, conducting public attitude surveys regarding solid waste issues, developing the implementation machinery for local solid waste programs, working with prospective vendors, markets and other key parties toward the implementation of local solid waste programs, serving on the Kansas Solid Waste Management Task Force to develop solid waste policy for Kansas (chaired the Special Wastes Committee and served on the Incineration Committee), and coordinating the solid waste planning for the most populous county in Kansas. In addition, Dr. Hahn's services were utilized by several other counties in Kansas as they dealt with their solid waste problems. Dr. Hahn has attended several national and regional solid waste conferences and is abreast of current solid waste management issues.

Dr. Hahn's work with Camp Dresser & McKee included several permitting and site assessment studies for the electric utility industries in the Great Lakes area, environmental baseline studies of uranium solution mines in Texas, radium uptake studies by water hyacinths in Texas, lake restoration in Florida, fish population and water quality studies in Indiana, and harbor assessment in Massachusetts.

During his career, Dr. Hahn has taught at the University of North Dakota and held professorships at Doane College in Nebraska, Wichita State University, and Friends University. He taught a variety of vertebrate zoology, field ecology, and environmental science courses. Early in his career, Dr. Hahn conducted aquatic biology and fisheries biology research including work on a national wildlife refuge and fish culture work on catfish and trout.

Dr. Hahn has also conducted scientific surveys of public opinion on various environmental issues, held numerous technical and research grants from a variety of sources, delivered formal presentations on various environmental topics to a large number of audiences, and authored numerous reports and publications.

PROFESSIONAL AFFILIATIONS

American Association for the Advancement of Science
American Fisheries Society
Beta Beta Beta Biological Honor Society
Ecological Society of America
Phi Beta Kappa
Water Pollution Control Federation

PUBLICATIONS

A list of publications is available upon request.

CHARLIE E. WESTERMAN

project management
laboratory management
client problem solving
environmental chemistry
data interpretation/report preparation
GC/MS
US EPA analytical methodologies
US EPA contract laboratory program (CLP)
data validation/laboratory evaluation
quality assurance/quality control
field sampling

EDUCATION

University of Arkansas, Ph.D., Physical Chemistry, 1973
University of Central Arkansas, B.S., Chemistry, 1965

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Consultant/Senior Project Scientist, 1990 - present.
ETC/Toxicon, Vice President and Technical Director, 1986 - 1989.
Toxicon Laboratories, Inc., Vice President and Technical Director, 1981 - 1986.
University of Tennessee Space Institute, Research Scientist, 1981.
Sverdrup Technology, Inc., Organic Analyst, 1980 - 1981.
Environmental Science and Engineering, Inc., Senior Staff Chemist, 1980.
Environmental Science and Engineering, Inc., Group Leader, GC/MS Group, 1978 - 1980.
Environmental Science and Engineering, Inc., Project Chemist, 1975 - 1978.
University of Florida, Postdoctoral Fellow, 1972 - 1975.
Veterans Administration Hospital, Chemist without compensation, 1972 - 1975.
University of Arkansas, Instructor (half-time), 1968 - 1972.
University of Arkansas, Graduate Fellow - Research Assistant, 1965 - 1972.

REPRESENTATIVE EXPERIENCE

Dr. Westerman joined Woodward-Clyde Consultants with 20 years of professional chemistry experience. This professional experience included 16 years commercial project management and environmental analytical service work with 14 years GC/MS supervisory experience and 8 years of laboratory management, 2 years academic biomedical analytical work, and 2 years university teaching in the areas of analytical, general, and physical chemistry.

At Woodward-Clyde he is a Senior Consultant/Senior Project Scientist and is the Group Leader for the Analytical Sciences, Data Management and Computer Services Group for the Louisiana/Mississippi/Arkansas Operating Unit. He prepares Sampling and Analysis Plans (SAPs) and Quality Assurance Project Plans (QAPPs), evaluates and selects analytical laboratories, assesses laboratory data, and provides recommendations for remediation to clients based on field and laboratory data.

As a Senior Consultant, Dr. Westerman provides his expertise throughout the firm in areas of environmental chemistry, problem solving, data interpretation/report preparation, peer review, GC/MS, US EPA analytical methodologies, US EPA Contract Laboratory Program (CLP), data validation/laboratory auditing, quality assurance/quality control, and field sampling.

As Vice President and Technical Director of ETC/Toxicon for the period 1986 to 1990, he directed project management and new program development. Prior to this he served as Vice President and Technical Director and managed the technical operations of the laboratory for 5 years. He provided a broad spectrum of analytical and field-sampling services emphasizing GC/MS and including sample preparation, GC, LC, AAS, ICP, and various conventional parameter characterizations.

Dr. Westerman directed Toxicon's active participation in the US EPA Contract Laboratory Program (CLP) beginning in 1983 which included multimedia, multiconcentration IFBs for both the organic and inorganic programs. He served as the project manager for both the US EPA inorganic and organic CLP projects during the initial formative stages and provided characterization of hazardous-waste samples from various Superfund sites with routine application of packed- and capillary-column GC/MS and GC/ECD for organics and graphite-furnace AAS and multielement ICP for heavy metals.

He managed diverse analytical-service work and consultation required by the Louisiana Department of Environmental Quality for its monitoring, surveillance, and enforcement programs during the interval 1981 through 1988 on separate contracts for the Hazardous Waste Management, Inactive and Abandoned Hazardous Waste Sites, Ground Water Protection, and Air Quality Divisions.

He managed two emergency contracts issued by the Hazardous Waste Management Division to provide analytical methods development, analytical methods validation, characterization of hazardous waste samples and consulting concerning sampling and analyses for the Livingston Train Derailment.

Dr. Westerman performed routine environmental-monitoring and industrial and environmental specialty work for private-sector clients. He provided problem-solving, rapid response, and consultation concerning sampling, analysis, and explanation of environmental regulations.

Prior to joining Toxicon, Dr. Westerman was employed as a research scientist for the Energy Conversion Division of the University of Tennessee Space Institute where he provided organic analysis of coal-gasification process streams. This work entailed sample preparation, wet-chemical fractionation, and analyses by GC/FID and GC/MS.

As an organic chemist at Sverdrup Technology, Inc., Dr. Westerman provided GC/MS data acquisition, data interpretation and evaluation, and final report preparation on US EPA hazardous waste and sludge Priority Pollutant IFBs.

At Environmental Science and Engineering, Inc., Dr. Westerman interfaced and functioned with professional and technical personnel from various disciplines to provide environmental assessments.

Following the 1976 Priority Pollutant Consent Decree, he established an extensive GC/MS analytical laboratory over a four year period selecting and installing GC/MS instrumentation and ancillary equipment and training and managing staff prior to the formation of a distinct GC/MS group.

He managed the operation of GC/MS analytical services, including analytical staff, two research-grade computerized GC/MS systems, and laboratory facilities, to provide the GC/MS analytical data on the EPA Effluent Guideline Division (EGD) screening and/or verification phase surveys for Best Available Technologies (BAT) for the Timber Products, Gum and Wood Chemicals, Printing and Publishing, Pesticides, and Miscellaneous Organic Chemicals segments.

He provided the GC/MS analytical data on the EPA EGD BAT project characterizing the effectiveness of carbon adsorption technology for the removal of Priority Pollutants from the wastewaters of organic chemical process wastewaters and served as Project

Manager for the EPA EGD BAT review of the Miscellaneous Organic Chemicals Industry. Analytical effort encompassed Priority Pollutants (less asbestos), by GC/MS, GC/ECD, and AAS and selected conventional parameters.

He designed field collection apparatus and performed GC/MS characterization of very low levels of Synthetic Organic Chemicals (SOCs) in the raw and treated drinking water supply of the City of North Miami Beach, Dade County, Florida. The work arose as an emergency response to public alarm and resulted in a long-term sampling and analysis program performed under court order where low-level semivolatile detection limits were achieved by accumulating organics from greater than 100 liters of water onto XAD macroreticular resin cartridges.

He designed and managed the Tenax GC field sample collection and GC/MS analytical characterization of organic vapors in ambient air. City-wide odor abatement study for Jacksonville, Florida.

He provided GC/MS characterization of purgeable volatile and semivolatile extractable Priority Pollutants and selected munitions by-products and decomposition products. USATHAMA multi-media environmental survey of Alabama Army Ammunition Plant to identify areas of significant contamination resulting from explosives manufactured in the early 1940s.

He contributed as project chemist on EPA Office of Toxic Substances (OTS) project to develop and implement multi-media monitoring program for the sampling and analysis of PCBs.

He contributed as project chemist on EPA study of hazardous waste disposal with the goal of energy resource recovery.

He managed fluoride monitoring program in central Florida to gain insight into the pressing fluorosis problem associated with phosphate processing.

As a postdoctoral fellow in the Department of Radiology of the University of Florida, Dr. Westerman participated in the isolation and identification of unknown metabolites in biological fluids of patients exhibiting neurological disorders. He applied proton and carbon-13 FTNMR spectroscopy and routinely analyzed a wide variety of samples including drugs, biological materials, and synthetics polymers. He developed empirical carbon-13 chemical-shift correlations with additive substituent increments to provide identification of various substituted aromatic acids in biological fluids. He also contributed to the establishment of microtechniques for sample preparation/manipulation.

Dr. Westerman served as an instructor in the Department of Chemistry at the University of Arkansas teaching a modern analytical chemistry lecture and laboratory course emphasizing instrumental methods. He also taught general chemistry and coordinated the physical chemistry laboratory program supervising laboratory assistants, maintaining equipment, selecting and designing experiments, and stocking the laboratory.

PROFESSIONAL AFFILIATION

American Chemical Society

PUBLICATIONS

Alley, E. G., B. R. Layton, J. P. Minyard, Jr., and C. E. Westerman, 1976, "Carbon-13 Nuclear Magnetic Resonance Investigation of Chlorinated Pentachloro-[$5.3.0.0^{2,6}.0^{3,9}.0^{4,8}$]decanes (Photodecomposition Products of Mirex)," J. Org. Chem., Vol. 41, P. 462.

Preste, P. G., C. E. Westerman, B. J. Wilder, N. P. Das, and J. H. Duncan, 1974, "Identification of 2-Ethyl-2-methyl-3-hydroxysuccinimide as a Major Metabolite of Ethosuxidmide in Humans," J. Phar. Sci., Vol. 63, p. 467.

Hinton, J. F. and C. E. Westerman, 1970, "NMR Studies of the Structure of Aqueous Solution-I. The Aqueous N-Methyl-oriouibanude System," Spectrochim. Acta., Vol. 26A, p. 1387.

DENNIS E. REECE

groundwater remediation
groundwater hydrology
groundwater modeling
environmental fate of chemicals
remedial investigation/feasibility studies
groundwater monitoring
regulatory compliance and permitting

EDUCATION

University of Idaho, M.S., Hydrology, 1977
University of Idaho, M.S., Chemistry, 1975
University of Idaho, B.S., Chemistry, 1972

EMPLOYMENT HISTORY

Technical Director/Division Manager, Woodward-Clyde Consultants, July 1989 - present
Engineering Manager/Project Director (last title), Houston Regional Office, IT Corporation, April 1980 - July 1989
Hydrogeologist II (last title), South Florida Water Management District, West Palm Beach, Florida, July 1977 - April 1980
Idaho Bureau of Mines and Geology, Geology Department and Chemistry Department, University of Idaho, Moscow, Idaho, various full time and part time positions as Research Associate or Research Assistant, January 1973 - June 1977 National Mining and Mineral Fuels Fellowship, 1976 - 1977

EXPERIENCE SUMMARY

Mr. Reece has over 13 years of professional experience in chemical site remediation, investigation and permitting and in ground water resource investigation. He has managed or executed numerous projects for RCRA, CERCLA, TSCA, and spill response sites in Louisiana, Texas and Arkansas. He also has extensive experience in mining and water resource projects in the Gulf Coast, midwestern and northwestern states. He has implemented ground water recovery projects for site remediation, dewatering and water supply, often proceeding from site characterization through design and construction. He is experienced in analytical and numerical modeling techniques for hydraulic and solute transport purposes. Mr. Reece also has considerable experience assessing environmental fate of chemical constituents. Mr. Reece has managed a number of large consulting projects and has been project manager of a construction management project for a 19 million dollar remediation project.

REPRESENTATIVE EXAMPLES

Mr. Reece has been Project Manager for subsurface projects at a major chemical manufacturing facility in Louisiana. Projects include three major groundwater assessments and subsurface assessments for all planned new construction projects. One major ground water assessment involves investigation of extent and concentration of chlorinated solvents in shallow ground water. Project involves risk assessment, extensive regulatory interface, preparation/documentation in support of possible litigation.

Overall Project Director and Manager of ground water tasks for full service project for an Arkansas chemical plant, including site investigation, permitting, and remedial design/remediation of impoundments, landfills and other waste facilities. Project involved closure of more than a dozen surface impoundments and landfills and design, installation and operation of three ground water recovery systems to remediate ground water containing halogenated organics, acid and brine.

Project Manager for the RI/FS and Project Director for remedial design of the Old Midland Products Superfund Site in Arkansas. Remediation involves onsite incineration of contaminated sludges and soils and ground water recovery and treatment with biological and activated carbon treatment.

Principal Investigator for ground water remediation project at a major chemical plant at a southeast Texas location. Project at this 150 acre site included recovery of free liquid phase and dissolved phase chlorinated solvents.

Project Manager for a RCRA facility investigation to characterize and evaluate closure/remediation of 30 surface impoundments and landfills at a major east Texas petroleum refinery. Project included work plan preparation, regulatory interface and implementation of the work plan.

Project Manager for a project that assisted a client in preparation of RCRA ground water corrective action plans for chlorinated solvent sites at chemical plants in Texas City and southwest Texas.

Project Manager for preparation of Part B Permit Application and Closure Plans for a major east Texas petroleum refinery. Project involved extensive field investigation including drilling, impoundment sampling, ground water monitoring and preparation of Part B documents and interim status closure plans.

Project Director for installation and operation of a ground water recovery system at a pesticide spill site in Houston. Consultant for groundwater investigation and design of recovery system for a chlorinated hydrocarbon site near Baton Rouge.

Project Coordinator and Field Manager for a major site investigation/feasibility study at the Geneva Industries Superfund Site. Project Manager for the remedial design. Project Director for construction management of a $16 million remediation of the Geneva Industries Superfund Site.

Project Manager, Gulf States Utilities, for surface impoundment project involving ground water quality assessment, impoundment closure and reopening as a nonhazardous impoundment.

Ground water consultant for monitoring and remediation at the former Vertac Chemical site near Jacksonville, Arkansas.

Prepared subsurface investigation during emergency response and remediation at an Arkansas train derailment site involving a spill from chemical tank cars.

Performed hydrogeologic site characterizations, RCRA monitor well installation, and preparation of RCRA regulatory documents of four petroleum refineries and numerous chemical plants in Louisiana and Texas.

Lead hydrogeologist for a comprehensive hydrogeologic computer modeling of a 200-mile section of the Red River Valley in northern Louisiana to predict ground water level changes resulting from construction of a series of locks and dams on the Red River.

Designed ground water monitoring network and performed aquifer tests for three lignite mining areas. Also prepared dewatering plans.

Performed geochemical/geohydrologic studies at several Strategic Petroleum Reserve sites in Texas and Louisiana.

PROFESSIONAL AFFILIATIONS

Member, Association of Ground Water Scientists and Engineers, National Water Well Association

PUBLICATIONS

Mr. Reece has authored 15 research papers/conference presentations including the following:

Reece, D. E., Monti, J., 1985, "Assessment of Influence of Complex Hydrogeologic and Geochemical Conditions on RCRA Ground Water Monitoring Results," presented at the Southern Regional Ground Water Conference of NWWA, September 18, 1985.

Reece, D. E., Chapin, R., 1985, "Example of the Influence of Degree of Chlorination on Subsurface Migration of Polychlorinated Biphenyls and Related Compounds," presented at the Southern Regional Ground Water Conference of NWWA, September 19, 1985.

Reece, D. E., Husak, A. D., Woolson, E. A. and Chapin, R. I., "Influence of chemical Species on Mobility of Subsurface Arsenic contamination," presented at NWWA/APE conference, Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, Restoration, November 5-7, 1984, Houston, Texas.

Murray, J. B., Reece, D. E., Husak, A. D., 1982, "Characterization and Retrofitting of Waste Disposal Sites," presented at the 1982 spring convention of the American Society of Civil Engineering, Las Vegas, Nevada.

Wai, C. M., Reece, D. E., Ralston, D. R., and Williams, R. E., 1980, "Production of Acid Water in a Lead-Zinc Mine, Coeur D'Alene, Idaho," Environmental Geology, Volume 3, pp. 159-162.

FRANCIS R. (BOB) SIENER, JR.

air quality
industrial hygiene
health & safety training
environmental health and safety auditing

EDUCATION

Tulane University, MPH, School of Public Health, 1981

Louisiana State University, B.S., Zoology, 1973

REGISTRATION

Certified Industrial Hygienist, American Board of Industrial Hygiene, #3965

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Project Scientist, 1988 - present

Tenneco Oil Company, Senior Environmentalist, 1985 - 1988

Tenneco Oil Company, Occupational Health Supervisor, 1981 - 1985

Tenneco Oil Company, Industrial Hygienist, 1978 - 1981

Avondale Shipyards, Industrial Hygienist, 1976 - 1978

Shilstone Testing Lab, Environmentalist, 1975 - 1976

Gulf South Research Institute, Environmental Biologist, 1974 - 1975

REPRESENTATIVE EXPERIENCE

Mr. Siener has fourteen years of professional experience in air pollution, environmental and occupational health and safety. He has had direct environmental experience in air permitting, compliance auditing, facility program development, compliance reporting, air dispersion modeling and underground injection control management.

Mr. Siener has prepared SARA/Right-to-Know reports, compiled toxic chemical emission inventories, performed air dispersion modeling and prepared community awareness communication programs.

Typical air compliance programs developed and managed were PSD and NSPS testing, monitoring and reporting, VOC and NESHAPS fugitive emission monitoring, emergency air release reporting and prevention, continuous emission monitoring, annual emission inventory reporting and TOSCA compliance.

Mr. Siener has a broad background in occupational health and safety. Industrial hygiene hazard recognition and evaluation includes experience in oil refineries, shipyards, foundries, appliance manufacturing, machine works and other small manufacturing industries.

Mr. Siener has provided project management for a major hazardous waste landfill remediation project. WCC provided environmental, health and safety oversight services during the field activities conducted in level B personal protective equipment. He has also provided instruction in OSHA and RCRA hazardous waste training courses.

Industrial hygiene surveys were performed under Mr. Siener's direction, including indoor air construction activities and asbestos surveys. Mr. Siener has conducted site assessments and health and safety auditing for various industrial and commercial clients. A perimeter monitoring survey was conducted for a pesticide remediation project.

Industrial hygiene programs have been established in air sampling, respiratory protection, hearing conservation, radiation protection, and asbestos abatement. A recordkeeping system for monitoring and medical surveillance records was developed and implemented.

A comprehensive medical examination program was designed and implemented for over 600 union and non-union employees. Establishment of an emergency response and rescue program and workers compensation management are also noted.

Mr. Siener has had experience with numerous governmental inspections including OSHA, EPA, DEQ, and TOSCA. He has served as expert witness and offered technical advise on health and safety litigation.

Numerous training courses in hazards evaluation, respiratory protection, asbestos abatement and noise control have been conducted by Mr. Siener.

General environmental experience includes aquatic data collection, identification and report writing for environmental impact statements. Clients included the Corps of Engineers and utility companies.

S. RUSSELL KILLEBREW

civil engineering
remedial investigation/design
project management

EDUCATION

U.S. Military Academy, West Point, NY, B.S., Civil Engineering, 1975.

REGISTRATION

Professional Engineer, Virginia, Arkansas and Mississippi

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Project Engineer, 1989 - present.
Rollins Environmental Services, Technical Representative, 1988 - 1989.
Exxon, USA, Construction Management/Civil Engineering, 1986 - 1988.
Exxon, USA, Drilling Engineer, 1982 - 1986.
U.S. Army Corps of Engineers, Captain, 1975 - 1982.

REPRESENTATIVE EXPERIENCE

Mr. Killebrew joined Woodward-Clyde Consultants as a Senior Project Engineer with over 15 years of professional experience in environmental/civil engineering, with expertise in remedial investigations, planning and design of remedial actions, and project management.

Since joining Woodward-Clyde, Mr. Killebrew has developed remedial strategies and the associated work plans, sampling and analysis plans, bid specifications, and QA/QC plans for a variety of projects. The selected remedial alternatives included dewatering, off-site incineration, on-site biological treatment, and deep well injection. Mr. Killebrew is the project manager for oversight of an Expedited Response Action at a local Superfund site.

Prior to joining the firm, Mr. Killebrew was employed with Rollins Environmental Services as a technical representative. In this position, he developed plans, estimates and bid proposals for the remediation of hazardous waste sites. He was responsible for project management and control to include cost tracking, progress reporting and resource scheduling. Project types included plant demolition, drum repacking, solidification, dewatering, excavation and site assessment for a variety of hazardous wastes including asbestos, PCB's, and arsenic. He was also the site supervisor for the Rose Chemical remediation project, the largest PCB Superfund site in the nation.

While employed with Exxon, USA, his primary responsibility was construction management to include writing specifications, preparing bid documents, evaluation of bids, scheduling, cost tracking, progress reporting, and post job evaluation. Mr. Killebrew also designed foundations and structural supports for process equipment and prepared construction cost estimates.

As a Drilling Engineer with Exxon, USA, Mr. Killebrew designed a total of 68 deep, high pressure oil and gas wells for a total cost of $34 million, at an average of 24% under budget. He also provided surveillance and engineering support to operations during drilling while simultaneously preparing detailed designs for up-coming wells. These designs included: casing design, hydraulic program, mud weight schedule, cementing design, directional drilling program, drill string design, and additional procedures and equipment specifications as needed.

As a Captain in the U.S. Army Corps of Engineers, he was directly responsible for the morale, welfare, discipline and training of up to 54 officers and enlisted men, and for the maintenance and operation of up to 13 vehicles or items of construction equipment. Mr. Killebrew was operations officer for the unit providing all Atomic Demolitions support in Southern Germany, coordinating and scheduling training and joint operations with both German and US Army Units. He designed and implemented a training program which substantially increased unit effectiveness as measured by numerous subsequent Nuclear Surety Inspections by headquarters up to Department of the Army level.

In addition to his formal education and professional experience, Mr. Killebrew has completed numerous continuing education programs in the field of environmental science/engineering, and construction project management.

AFFILIATIONS

Society of American Military Engineers
U.S. Army Reserve, Corps of Engineers, Top Secret clearance

JUNE L. SUTHERLIN

toxicology
risk analysis

EDUCATION

Louisiana State University, Toxicology, Ph.D. Candidate, 1990
Louisiana State University School of Veterinary Medicine, Doctor of Veterinary Medicine, 1985

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Toxicologist, 1989 - Present
Louisiana State University - SVM, Graduate Research Assistant, 1988 - 1989
Private Practice, Veterinarian, 1985 - 1987

REPRESENTATIVE EXPERIENCE

Dr. Sutherlin's project involvement has included a wide range of activities, including the determination of toxicological properties, environmental release and potential exposure pathways, chemical intake of receptor population, and risks associated with specific exposure scenarios.

Risk Assessment

- Currently performing a health risk assessment for the evaluation of chemical constituents present in the soil and groundwater for the development of site-specific, health-based remedial criteria for a refinery site.

- Conducted a risk assessment for a major industrial client, involving the evaluation of the potential health effects of solvents and herbicides released into the workplace and environment, including a health-based evaluation of proposed remedial alternatives.

- An evaluation of a work plan prepared for the Original Process Waste Lines, Operating Unit 09, US DOE, Rocky Flats Plant, with respect to the plan's ability to provide efficient information of adequate quality to perform a health risk assessment. This project involved identifying deficiencies in the plan, providing recommendations to correct the deficiencies, and evaluating the consequences of implementing and not implementing the recommended changes.

- Peer review/evaluation of health risk assessments prepared for a major industrial client.

Toxicological Assessment

Ms. Sutherlin has conducted a toxicological assessment of PCB contamination for a major natural gas pipeline client. Specific project activities have included:

- An assessment of the role of pharmacokinetics and other attenuating factors in the estimation of risk associated with the consumption of PCB contaminated fish.

- Nationwide cattle testing for the evaluation of tissue residues subsequent to PCB exposure.

- An evaluation of the relationships between PCB exposure, biotransformation, and congener deposition in aquatic species.

- A comprehensive evaluation of environmental sources of PCBs and potential exposure scenarios and their potential correlation with site characterization data.

- An assessment of preliminary PCB field sampling results and the formulation of a sampling plan for site characterization and risk assessment purposes.

Other project involvement has included:

- Preparation of toxicological profiles for the chemicals of concern for the assessment of risk associated with potential exposure to heavy metal contamination present at a major industrial plant, the incineration of Basin F liquids at the Rocky Mountain Arsenal, and chemical constituents present at a utility company.

- Toxicological assessment of a mixed hazardous waste material and the preparation of health and safety information for the handling of the material prior to incineration.

- An evaluation of the experimental design and resulting conclusions of animal toxicity tests conducted for the assessment of the potential toxicity associated with exposure to recycled waste product for a major industrial client.

Exposure Assessment

- The calculation of acceptable exposure concentrations for a residential receptor population located adjacent to a Superfund site for the development of on-site monitoring guidelines during the implementation of remedial activities.

Supplementary Experience

- Currently involved in comparative xenobiotic oxidative biotransformation research in domestic species involving the induction of hepatic microsomal enzymes subsequent to PAH exposures.

- Co-author of report entitled, "Reproduction and Development: Mechanisms and Effects of Xenobiotics," prepared for Geismar Area Industrial Technical Group.

MICHAEL J. SCHWARTZ

geology
hydrogeology
groundwater projects

EDUCATION

University of New Orleans: B.S., Geology, 1987.

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Staff Geologist, 1989 - present.
Geophysical Trend Corporation, Geoscientist, 1987 - 1989.
Minerals Management Service, Geologic Technician, 1984 - 1987.

REPRESENTATIVE EXPERIENCE

Mr. Schwartz has been involved in a variety of projects since joining Woodward-Clyde Consultants, providing strong professional and technical support in both the field and office. Mr. Schwartz produces high quality work on a timely basis.

Mr. Schwartz is knowledgeable in the acquisition, analysis and interpretation of geological, geomorphological and hydrogeological data as the following list of projects demonstrates:

- Geologist on a lake sediment characterization project. Assisted in the delineation of the project areas ancestral drainage pattern by analyzing aerial photography and using sonar equipment to map the lake bottom geomorphology. Identified vibracore sample points and responsible for making geologic logs.
- Research team member committed to a long-term coastal geomorphology project studying the effects of wave-action on a back barrier marsh environment by measuring rates of sedimentation and erosion.
- Geologist in charge of collecting environmental samples and analyzing hydrogeologic data for a number of underground storage tank site assessments, along with interpreting and making conclusions on investigation findings in written reports.
- Field mapping of contaminated soils zone on a property transaction project.
- Collecting and analyzing samples from a number of geotechnical investigations throughout Louisiana.
- Involved in a number of groundwater sampling and monitoring plans for hazardous waste landfills and chemical companies.
- Supervisor of contractor quality assurance/quality control program during the placement of a gradient control drainage system.

AFFILIATIONS

National Well Water Association
Association of Groundwater Scientists and Engineers
Houston Geological Society
Geophysical Society of Houston
American Association of Petroleum Geologists

JOHN V. CONNER

aquatic/marine biology 4 00312
fisheries biology
wetlands ecology
environmental affairs/permitting
biofouling prevention/control
pond/lake management
waste management

EDUCATION

Tulane University, Ph.D., Biology, 1977
Texas A & M University, M.S., Fisheries Science, 1966
Texas A & M University, B.S., Wildlife Management and Journalism, 1964

REGISTRATION

Certified Fisheries Scientist - #1426

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Project Scientist, May 1990 - Present.
Gulf States Utilities Company, River Bend Station, St. Francisville, Louisiana, Supervisor-Environmental Services, March 1983 - April 1990.
Gulf States Utilities Company, River Bend Station, St. Francisville, Louisiana, Environmental Specialist, April 1982 - March 1983.
U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, Fisheries Research Biologist, May 1981 - April 1982 (part-time intergovernment appointment).
Louisiana State University, Baton Rouge, Louisiana, Assistant Professor of Fisheries, January 1972 - March 1982.
Tulane University, New Orleans, Louisiana, Graduate Teaching Assistant, 1970 - 1971.
East Pakistan Agricultural University, Mymensingh, East Pakistan, Advisor to Faculty of Fisheries (under USAID contract), 1969 - 1970.
Texas A & M University, College Station, Texas, Instructor/Research Associate, 1965 - 1969.

REPRESENTATIVE EXPERIENCE

Dr. Conner has more than 25 years of experience in environmental management, research, and education. His direct experience includes management and technical direction of regulatory compliance programs, biological surveys, field ecological research (primarily freshwater and estuarine), regulatory review and interpretation, impact assessments and siting studies, biofouling prevention and control, pond/lake management and aquaculture, spill/contingency plan development, spill response, waste management, regulatory liaison and permitting, and teaching.

Prior to joining Woodward-Clyde, Dr. Conner was Environmental Supervisor at a nuclear-fueled steam electric generating plant on the Mississippi River in West Feliciana Parish, Louisiana. He was responsible for developing and implementing programs required for environmental regulatory compliance and fulfillment of numerous commitments relating to environmental protection, resource conservation, and public education. Regulatory compliance programs included radiological monitoring, meteorological monitoring, water quality monitoring, oil/chemical spill prevention and control, solid and hazardous waste management, environmental noise monitoring, cooling tower salt-drift assessment, SARA Title III chemical inventories and reports, and Asiatic clam detection and control. Environmental commitments included land, timber and wildlife management on the 3,800-acre site; groundwater hydrology monitoring; erosion control; and provision for public use of the property for environmental education and research.

Before direct employment with Gulf States Utilities Company, Dr. Conner was a member of the fisheries faculty at Louisiana State University. His primary responsibility was research as director of the large-scale, multidisciplinary studies needed for the siting and permitting of the aforementioned nuclear facility. This work entailed extensive baseline surveys of environmental conditions and biotic community structure in the Mississippi River, adjacent bottomlands, and uplands. Innovative methods were developed for sampling of the river and swamp environments, leading to significant discoveries which fostered further studies of these types of systems. He became technical supervisor of a major contract supporting larval fish investigations by the Army Corps of Engineers in the Mississippi River in Arkansas. Dr. Conner also worked as co-supervisor or major contributor on projects related to: 1) siting/routing of onshore facilities for the Louisiana Offshore Oil Port (LOOP); 2) water quality and aquatic community structure in the Atchafalaya Basin; 3) development of criteria for definition of Louisiana's coastal zone. and 4) assessment of natural reproduction of the introduced grass carp in the lower Mississippi River system.

While on the faculty of Texas A&M University, Dr. Conner was field supervisor for two major contracted research efforts; 1) low-salinity marsh use by young marine fishes and crustaceans; and 2) impacts of thermal effluents on fishers in four reservoirs and a portion of Galveston Bay. He assisted numerous private landowners in troubleshooting or managing pond and lakes.

During his career, Dr. Conner has consulted independently to various companies and agencies regarding impact assessment, monitoring program design and implementation, and industrial or public works siting problems. He has conducted or participated in studies of effluents from paper mills, power plants, and oil and gas production/distribution facilities. Dr. Conner has given expert testimony in various trials and hearings, as well as providing technical advice in case preparation related to environmental litigation. Dr. Conner has authored numerous articles and delivered formal presentations at regional, national, and international professional gatherings.

PROFESSIONAL AFFILIATIONS

American Fisheries Society
Water Pollution Control Federation

Woodward-Clyde Consultants

SETPHEN W. FLETCHER

senior ecologist
reclamation and environmental analysis

EDUCATION

Duke University, Ph.D., Botany, 1975
Duke University, M.A., Botany, 1971
Washington and Lee University, B.S., Biology, 1969

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Assistant Project Scientist, 1991 - Present
S.W. Fletcher & Associates, Principal, Senior Scientist, 1983 - 1991
Environmental Science and Engineering, Inc., Acting Department Manager, 1981 - 1983
Environmental Science and Engineering, Inc., Terrestrial Ecology Group Leader, 1980 - 1983
Environmental Science and Engineering, Inc., Staff Scientist, 1976 - 1980

AREAS OF SPECIALIZATION

Vegetation Mapping and Analysis, Wetlands Delineation and Analysis, Community Classification, Photogrammetry and Remote Sensing, Habitat Evaluations, Reclamation Planning, Ecological Effects of Hydrological Modifications, Dredge and Fill and Surface Water Permitting, Biological Monitoring, Plant Stress Surveys.

REPRESENTATIVE EXPERIENCE

Power Plant Licensing. Project Manager - Terrestrial ecology and wetlands aspects of Site Certification and EIS study for proposed 3,200 MW generating facility at sensitive Cockroach Bay on Tampa Bay. Project involved coastal wetlands, nursery areas, sand flats, endangered species, and agricultural land uses, Tampa Electric Company.

Power Plant Siting. Subproject Manager - Terrestrial and wetlands ecology aspects for six county site selection study for power plant site in central and southwest Florida. Aerial photos and satellite imagery used for mapping of wetlands. Tampa Electric Company.

Power Plant Siting and Licensing. Subproject Manager - Terrestrial ecology and wetlands for SCA and Environmental Report study for two proposed 1,600 MW power facilities in Gulf and Osceola Counties. Sensitive issues included large areas of wetlands and lakeshores. Florida Power Corp. Mid-80's Units.

Corridor Siting. Corridor Siting Manager - for 200 miles of transmission line in northwestern and north Florida in conjunction with mid-80's units, with evaluation of land use, structures, wetlands, river crossings, and ecological features. Remote sensing methods included satellite imagery, high altitude aerials, and video imagery. Florida Power Corp.

Power Plant Licensing. Subproject Manager - Terrestrial and wetlands ecology aspects of Site Certification Application and third-party EIS for Crystal River Units 4 and 5 coal-fired power plants. conducted baseline ecological studies, delineation of wetlands, inventory of timber resources, and assessment of impacts. Florida Power Corp.

Power Plant Impact Assessments. Project Scientist - Evaluation of impact potential of additional slat water cooling tower configurations for salt drift effects on vegetation at Crystal River power complex. Florida Power Corp.

Power Plant Impact Assessment. Project Scientist - Long-term monitoring of vegetation for potential salt drift effects from Units 4 and 5 salt water cooling towers at Crystal River power complex. Florida Power Corp.

Transmission Corridor Licensing. Project Manager - Threatened and endangered species analyses for several transmission line/distribution project in southern and eastern Georgia for submittal to the Rural Electrification Administration. Oglethorpe Electric.

Expert Testimony. Project Manager - Site selection and Site Certification of 230 KV, 50-mile Orlando-Lakeland transmission line through Green Swamp Area of Critical State Concern included wetland delineation, endangered species assessment, soil and vegetation mapping, and dredge and fill permitting. Expert testimony at Site Certification hearings on effects on wetlands resulted in first variance to and only transmission line permitted under the Green Swamp regulations. Orlando Utilities.

Power Plant Certification. Project Manager/Project Scientist - Terrestrial and wetland aspects for SCA fur Curtis H. Stanton Energy Center in Orange County, Florida. Project involved wetlands, red-cockaded woodpecker and scrub jay studies and management plans, corridor assessments and river crossing evaluations for 415-MW coal-fired plant. Orlando Utilities Commission.

Power Plant Licensing. Project Scientist - Author of fatal flaw methodology for identifying licensing problems based on interactions impacts, existing resources, and jurisdictional authorities, used in evaluation of licensing potential for power plant site in Martin County. Florida Power and Light.

Transmission Corridor Siting. Project Scientist - Developer of node-based transmission corridor siting methodology and screening criteria based on overlay techniques preceding from a regional level to local levels for alternative corridor segments. Florida Power and Light.

Power Plant Licensing. Project Manager - Licensing and environmental studies for proposed 440-MW generating facility in southern Illinois and development of all impact study plans for EIS. Southern Illinois Power Cooperative, Inc.

Power Plant Licensing. Subproject Manager - Selection and evaluation of proposed sites, including Wabash River site, for power plant, and corridor selection study for transmission lines in Illinois. Soyland Power Cooperative.

Power Plant and Corridors Licensing. Subproject Manager/Project Scientist - ecological studies for licensing of power plant, 27 miles of transmission line, and 33 miles of pipeline in New Jersey. Atlantic City Electric.

Power Plant Licensing. Subproject Manager/Project Scientist - Power plant licensing/EIS study for power complex site in Virginia/Maryland. Potomac Electric Corp.

Dredge and Fill Permits, Wetlands Delineations. Project Scientist - Delineation of about 1,000 acres of wetland son North Bradley and South Pebbledale phosphate mine sites in Polk County. Project included sampling and characterization of swamp and marsh vegetation for use in designing mitigation areas to replace mined wetlands. IMC Phosphate, Inc.

Dredge and Fill Permits, Wetland Delineations. Project Scientist - Delineation and mapping of about 5 miles of wetland boundaries on Hopewell phosphate mine property and along Lake Branch in Hillsborough County. IMC Phosphate, Inc.

DRI, Polk County Permits. Project Scientist - Delineation of COE, DER, SWFWMD, and Polk County wetlands based on vegetation, hydrologic connections, and soil types for 4,000-acre development near Lake Wales with about 1,500 acres of wetlands. Also mapping and evaluation of upland habitats including xeric habitats, and assessment of endangered species including gopher tortoise, kestrel, and burrowing owl. 5-R Ranch.

Development Permits. Project Manager - All ecological aspects of permitting 1,000-acre development in sensitive area near Econlockhatohee River in Seminole County, including wetlands mapping and permitting, gopher tortoise and scrub jay surveys, and hydroperiod determinations for SJRWMD storm water management plan.

Development Permits. Project Manager - Mapping of vegetation, wetlands, and habitats on 300-acre site in Collier County. Evaluation of xeric habitats for gopher tortoise and scrub jay populations, Phase 1 hazardous water survey, and county permitting process. Ericson Properties.

Site Assessment. Project Scientist - Preliminary evaluation of 1,000-acre pine/cypress/melalaca site in Ft. Myers for potential permitting problems and development potential. Mapping and evaluation of wetlands, floodplains, and threatened species habitat.

Site Assessment. Project Scientist - Preliminary evaluation of 800-acre site on Manatee River in Manatee County included wetlands and habitat mapping, floodplain evaluation, and endangered species evaluation.

Chesapeake Bay Wetlands Evaluation. Project Manager - Environmental inventory for Talbot County, Maryland Chesapeake Bay Critical Area Plan, including mapping and assessment of coastal and riparian wetlands of bay and coastal streams.

Wetlands Delineations and Site Assessment. Pre-development delineation and mapping of wetlands, evaluation of habitats and endangered species occurrence, floodplains and drainage. Staking of wetlands and site surveys with COE, WMD, and County regulatory personnel. Five sites in Sarasota County, 2 sites in Manatee County, 1 site in Polk County, 2 sites in Pasco County, 1 site in Hernando County, 2 sites in Osceola County, 1 site in Citrus County, 1 site in Alachua County.

Wetlands Delineation Methodology Development. Project Manager - Development and analysis of methods for jurisdictional delineation of wetlands in central and southern United States. Two technical reports from Corps of Engineers Waterways Experiment Station resulted from studies, one authored by Dr. Fletcher.

Dredge and Fill Permitting. Senior Scientist - Permitting of encroachment into portions of five freshwater marshes and crossing of five channels for residential project in Sarasota County. Permits obtained from DER and COE (Dredge & Fill), SWFWMD (MSSW), and Sarasota County (Zoning and Construction). Radnor Corporation.

Wetlands Jurisdictional Determination. Senior Scientist - Determination and staking of COE/DER/SWFWMD wetlands jurisdictional lines for 900-acre site in Pasco County. Project included nine isolated wetlands and over three linear miles of large cypress/hardwood swamp system as tributary to Cypress Creek. Project also involved determination of seasonal high water for MSSW and documentation of dewatering effects of adjacent well field. Saddlewood Estates development.

Wetlands Jurisdictional Determination. Task Manager - Determination of wetlands jurisdictional boundaries and documentation for three projects in Hillsborough County for COE, DER, SWFWMD, and EPC.

Revision of Jurisdictional Boundaries. Project Manager - Determined that jurisdictional line previously set by Hillsborough County EPC was not valid and persuaded EPC to revise line (without reapplication fee). Revision resulted in property made suitable for development. La Petite Academy.

Wetlands Jurisdictional Determination. Project Manager - Staking of wetlands boundaries and establishing seasonal high water elevations for 400-acre development in Sarasota County. Sawgrass Hollow development.

Experimental Wetlands Reclamation. Project Manager - Designer of two experimental wetlands reclamation projects for Farmland Industries' phosphate mining operations, including experimental sand-clay mixture, and recreation of natural stream/wetland complex with hydraulic specifications, stream meander design, and wetland plant and hydroperiod specifications.

Wetlands Mitigation Design. Project Manager - Developed plan for creation of marsh in upland habitat as mitigation to replace herbaceous soft rush/bloodroot marsh lost through filling. Plan included monitoring provisions and conceptual mitigation plan which were approved by Hillsborough County EPC.

Wetlands Mitigation Design. Project Manager - Design of three mitigation areas for replacement of natural freshwater marshes lost through encroachment in Sarasota County.

Wetlands Creation Design. Project Manager - Design of three alternatives for a 3-acre wetland/swale complex on sloping area to provide drainage and aesthetic appeal for golf course complex, while providing freshwater marsh and swamp habitat.

Littoral Zone Restoration. Project Manager - Management of restoration activities for three midwestern lakes invaded by cattails includes control of cattail, lake drawdown for sediment consolidation, and restoration of desirable wetland species.

Lake Littoral Zone Creation. Project Scientist - Preparation of wetlands and transitional areas planting design and specifications for 17 acres of littoral zones in 26 lakes developed for golf course project, incorporating floating plant, emergent herbaceous plant, and forested zones.

Restoration and Alternatives Plans Assessment. Project Manager - Author of report evaluating status of created wetland and evaluating alternative methods for control of nuisance species and restoration of wetland, which included assessment of past and project successional patterns, evaluation of hydroperiod and causes of nuisance species invasion, and evaluations and recommendations for restoration.

Wetlands Restoration. Project Manager - Preparation of detailed plan for restoration of wetland dewatered by drainage alternations included provisions for hydroperiod enhancement, removal of nuisance species, and habitat improvement by hardwoods plantings.

Wetlands Jurisdictional Determination. Subproject Manager - Delineation of wetlands boundaries under pre-1984 DER rules for phosphate mine. Conducted extensive vegetation, hydrological, and elevational survey sot document lack of jurisdictional connections for possible court case. Work led to compromise agreement and permit to mine disputed areas. Hardee County. Farmland Industries.

Wetlands Evaluation. Subproject Manager - Mapping and evaluation of wetlands on Pine Level mine site and development of wetlands qualitative evaluation ranking system for determination of EPA standards for mining, restoration, and preservation. Manatee and DeSoto Counties. AMAX Phosphate.

Phosphate Mine Permitting. Project Scientist - Ecological aspects of DRI studies for Mississippi Chemical Corp. mine site in Hardee County.

Phosphate Mine and Chemical Plant Permitting. Subproject Manager - Terrestrial, aquatic, and wetlands ecology aspects of DRI and Dredge and Fill permitting for proposed phosphate mine and chemical plant site in Hardee County. Farmland Industries.

Wetlands Evaluation. Subproject Manager - Evaluation of CF mine site Mitchells Hammock area for determination of preservation or restoration status for EPA third party EIS. Hardee County. CF Phosphate.

Air Quality Assessment. Project Scientist - Terrestrial resources aspects of state-wide study for utilities group to assess potential acid rain impacts in Florida included assessment impacts on native vegetation and agricultural resources. Florida Coordinating Group.

Air Quality Impacts. Project Manager - Review of evidence concerning damages to plants growing in central Florida greenhouse and assessment of probability of cause of damage by SO2 emissions.

Air Quality Impacts. Project Scientist - Evaluation of effects of bauxite release on vegetation near aluminum smelter in Louisiana.

Stress Assessment. Project Scientist - Environmental evaluation of landfill containing potentially hazardous materials on the shore of the Mississippi River, Louisiana.

Submittal of Expert Testimony. Subproject Manager - Submittal of expert testimony for Site Certification hearing for EPC Crystal River power plant in Citrus County. Interaction with lawyers in preparing questions and responses.

Expert Testimony. Project Manager - Polk County zoning hearings for permits for 230-KV power transmission line.

Wetlands and Vegetation Mapping. Senior Scientist - Mapping of wetlands and natural vegetation throughout 600 square miles of Pasco County at scale of 1" - 200' for Growth Management Plan. Devised modification of Natural Areas Inventory classification system used to generate 600 separate maps covering entire county based on blue-line and true color aerial photos.

Wetlands and Vegetation Mapping. Subproject Manager - Sensitive features, land use, and environmental assessment. Section 209 Areawide Water Quality Management Plan of Tampa Bay Region. Mapping of land use, forest and wetland vegetation, sensitive areas, hydrologic resources and other systems throughout Pinellas, Hillsborough, Pasco, and Manatee County 4-county region. Tampa Bay Regional Planning Council.

Similar projects for Tallahassee-Leon County, Southwest Florida, and Macon-Bibb County, Georgia.

EIS for Wetlands Impacts. Subproject Manager - Evaluation of vegetation stress and potential changes due to hydrologic alteration of circulation on a Georgia barrier island.

Vegetation Survey. Subproject Manager - Classification of vegetation along coastal creeks and marshes to determine saline influence and potential effects of water quality and hydrologic modifications on vegetation due to a proposed peat harvesting operation in North Carolina.

Vegetation Survey. Subproject Manager - Evaluation of salt and brackish marsh communities and analysis of successional progress on old dredge spoil islands in the Charleston River, South Carolina for proposed LNG terminal.

Wetlands Regulations. Subproject Manager - Evaluation of proposed modifications to Florida DER plant species list for determination of jurisdiction under dredge and fill permitting with responses for submittal by law firm covering species validity and effects on jurisdictional extent. Also preparation of several dredge and fill permitting applications.

PROFESSIONAL AFFILIATIONS

Ecological Society of America
American Society for Surface Mining and Reclamation
Association of State Wetlands Managers
American Society for Photogrammetry and Remote Sensing
Society for Ecological Restoration and Management
Soil and Water Conservation Society
Florida Academy of Science

JOHN P. HARVAT

permitting
aquatic ecology
water resources
mining

EDUCATION

University of Minnesota, M.S., Entomology and Fisheries, 1979
University of Minnesota, B.S., Biology, 1973

REGISTRATIONS

Certified Fisheries Scientist
Registered Environmental Professional (Pending)

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Project Scientist, 1989 - Present
Morrison-Knudsen Company, Inc., Staff Environmental Specialist, 1986 - 1989
Morrison-Knudsen Company, Inc., Senior Environmentalist, 1980 - 1986
Barr Engineering Company, Group Manager, 1979 - 1980
Barr Engineering Company, Project Manager, 1975 - 1979
Barr Engineering Company, Field and Laboratory Coordinator, 1974 - 1975
Barr Engineering Company, Technician, 1973 - 1974

REPRESENTATIVE EXPERIENCE

Mr. Harvat joined Woodward Clyde Consultants as a Senior Project Scientist in June 1989. Since that time he as worked on several projects. Examples of his responsibilities include:

- NPDES Permitting - oil and gas facilities, hydropower, hazardous waste landfills.
- New Source Project Permitting (Land and Water) - oil processing plant.
- Response to Regulatory Compliance Orders - salt mines, oil and gas facilities.
- Environmental Assessments - FERC filing.

Prior to joining Woodward-Clyde Consultants, Mr. Harvat gained extensive experience in baseline environmental studies, permitting, and project management, with efforts focused primarily on the surface mining industry. Examples of his project management experience include:

- Ecological Studies - surface mine expansion projects.
- Environmental Impact Statements - new source lignite surface mines, coal transshipment facility.

- Surface Mine Permitting - mining, water (quality and quantity), public road alterations, Section 7, Section 404 and SPGP (Texas), Section 106 consultation.

- Solid Waste Permitting - hazardous substances.

- Expert Testimony at Public Hearings

- Aquatic Baseline Studies - urban and mining environments.

- Lake Restoration Studies.

- Non-Point Source Runoff Studies.

- Water Quality Laboratory Technician and Manager

- Preliminary Hazardous Waste Site Investigation

PROFESSIONAL AFFILIATIONS

American Fisheries Society
North American Benthological Society
American Society of Limnology and Oceanography

BYRON J. BECNEL

geology
geochemistry
petroleum engineering
groundwater assessment and remediation

EDUCATION

Louisiana State University, B.S., Petroleum Engineering, 1985.

REGISTRATION

E.I.T.

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Staff Engineer, 1990 - present.

G & E Engineering, Inc., Project Environmental Specialist, 1988 - 1990.

City of Wichita Fall-Engineering Department, Engineering Technician, 1986 - 1988.

REPRESENTATIVE EXPERIENCE

As project environmental specialist for G&E, Mr. Becnel was responsible for technical and field investigation of groundwater remediation, geotechnical, geophysical, and groundwater monitoring projects. He was also involved in construction oversight activities on projects where remediation work is included.

He has considerable experience both from a design and implementation perspective. As an engineering technician for the City of Wichita Falls, he was responsible for assistance in design of highways, streets, and construction projects (including in-field designs and changes); inspection and supervision of construction work on these projects in accordance with design; lab and field analytical testing of soils, concrete, and asphaltic concrete. He has been involved in a number of projects involving the installation of water wells, monitoring wells, and other subsurface boring/augering techniques.

Mr. Becnel is well versed in sampling protocols and has conducted a significant number of laboratory and field analytical tests on soils and groundwater including Atterberg limits, pH and conductivity testing and field permeability testing. He is well versed in the use of field testing equipment including equipment used for HNU photoionization testing, explosive limits testing of vapors, phase measurements, and personal protection. He is also and experienced surveyors.

Mr. Becnel has spent time in the field logging drilling activities during the development and installation of water and monitoring wells and auger borings; and in addition, he has developed these wells upon completion.

Project experience includes field investigations (including underground storage tank leaks), site assessments, sample extraction and analytical evaluation of contaminated groundwater and soils, construction oversight and management.

His laboratory and field analytical testing experiences include density testing, optimum moisture content, % asphalt testing, % compaction in soil, grain and sieve analysis, porosity testing, compressive and tensile strength in concrete; use of density and asphalt content gauges.

AFFILIATIONS

Society of Petroleum Engineers
National Society of Professional Engineers
Louisiana Engineering Society

Woodward-Clyde Consultants

GARY W. DEVALL

industrial hygiene
health and safety training
field investigations
environmental regulations

EDUCATION

Louisiana State University, BS, Industrial Technology, Occupational Safety and Health, 1986

CERTIFICATIONS

Associate Safety Professional (ASP), Certification No. A3828

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Staff Scientist, 1989-Present
Arkla Energy Resources, Safety Administrator, Shreveport, Louisiana 1988-1989
Arkla Energy Resources, Safety Representative, Shreveport, Louisiana, 1986-1988.

REPRESENTATIVE EXPERIENCE

Mr. Devall has four years of professional experience in occupational and environmental health and safety. He has obtained specific environmental experience in areas such as industrial hygiene monitoring, soil and water sampling, development and implementation of health and safety plans, developing proposals for industrial hygiene services, and conducting OSHA mandated health and safety training.

Industrial hygiene services have been conducted by Mr. Devall in the areas of air quality, respiratory protection, and hearing conservation. The client base for these services include the natural gas transmission and processing industry as well as the hazardous waste site industry.

Mr. Devall has a broad background in industrial health and safety training. Training courses in the general industry standards (29 CFR 1910) and specifically hazardous waste site worker training (29 CFR 1910.120) has been developed and conducted by Mr. Devall.

Compliance programs for OSHA Hazard Communication and EPA SARA Title III have been developed and implemented by Mr. Devall. This service has been conducted in both the natural gas and petrochemical industries.

Besides academic and field experience, Mr. Devall has received additional professional knowledge and training by attending seminars covering subject matter such as asbestos abatement, safety management, underground storage tanks, safety and environmental compliance, PCB contamination and remediation, etc.

PROFESSIONAL AFFILIATIONS:

American Industrial Hygiene Association (AIHA)
American Society of Safety Engineers (ASSE)
Louisiana Environmental Federation
Louisiana Environmental Health Association

DIANE WEIGAND

industrial hygiene
OSHA compliance
hazardous communications training
program development

EDUCATION

University of Arizona: B.S., Biology, 1978

Our Lady of Holy Cross College, 1976

University of New Orleans: 1975

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Asst. Project Scientist, 1990-present.

US Department of Labor/OSHA, Industrial Hygienist Compliance Officer, 1986-1990.

Louisiana State University, School of Veterinary Medicine, Veterinary Laboratory Tech II, 1979-1981.

US Department of Agriculture-Animal and Plant Inspection Service, Biological Aid, 1978-1979.

REPRESENTATIVE EXPERIENCE

Ms. Weigand has four years of professional experience assessing workplace safety and health regulations. Industrial hygiene hazard recognition and evaluation includes the following industries: petroleum, refining, aerospace, manufacturing (chemical, paper, clothing, forklift, pipe), lead smelting, hospitals, funeral homes, maritime, asbestos abatement, construction bottling and canning, and governmental agencies. She has performed personnel exposure monitoring and surface sampling where applicable for: noise, lead, carbon monoxide, carbon dioxide, asbestos, welding fumes, organic vapors, isocyanates, chlorine, pesticides, ammonia, formaldehyde, styrene, ethylene oxide, dust and heat stress.

Ms. Weigand has provided technical guidance to employers, employees, union officials, governmental agencies and general public on health and safety related matters through research of OSHA standards, NIOSH criteria documents, general industry practice, NTIS, and CDC guidelines.

Ms. Weigand has prepared thorough, well documented reports which include discussion of processes, monitoring strategy, exposure determination, assessment of health programs, diagrams, photographs, interpretation of monitoring data analysis, citation recommendations and penalty assessment in accordance with the OSHA Field Operations Manual.

RECENT PRESENTATIONS

OSHA's Asbestos Standards and Inspection Procedures. Asbestos Training Center of Louisiana State University 1986.

OSHA's Asbestos Standard. University of Texas 1986.

OSHA's Asbestos Standard for Abatement Workers and Supervisors. The Laborers International Union of North America. 1986, 1987, 1989.

Industrial Hygiene Monitoring Techniques and Equipment. Louisiana State University. 1987, 1988.

AFFILIATIONS

American Industrial Hygiene Association
AHA-CPR, Instructor Trainer and examiner for the national registry examination for paramedics.

PERUMAL MOHAN

database management
software systems design & implementation
air dispersion modeling
waste water treatment concepts
data acquisition
data communication

EDUCATION

Louisiana State University, M.S., Systems Science, 1986
University of Windsor, M.Sc., Chemical Engineering, 1984
University of Madras (India), B.Tech., Chemical Engineering, 1982

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Assistant Project Engineer, 1989-Present
Physical Plant, Louisiana State University, Administrative Analyst, 1986-1989

REPRESENTATIVE EXPERIENCE

Mr. Mohan has had the following hands-on work experience:

Database & System Design

- o Designed, developed and implemented
  - Sample Information Management System
  - Creel Survey Information System
  - Project Management System
  - Work Order Management System
  - Utility Management System
  - Equipment,Tool Room & Warehouse Inventory Control System
  - Energy Management Scheduling System
  - Leave Tracking System

Air Dispersion Modeling

- o Modeled, analyzed and interpreted air dispersion of various chemicals for many industrial clients using EPA approved computer models.
- o Helped clients with SARA Title III and Emission Inventory System requirements compliance

Wastewater Treatment Concepts

- o Participated in conceptual design of wastewater minimization and reduction study of EDC/VCM and other plants

Data Acquisition

- o Designed conceptually, a data acquisition and management system for automatic leachate collection system for landfills

Networks

- o Configured and installed an IBM Token Ring Network
- o Network Administrator for IBM Token Ring Network
- o Involved in planning and implementing of 3COM Network

Communications

- o Established remote access to Token Ring Network
- o Connected Token Ring Network through a Gateway to IBM 370/3090
- o Established access to The Energy Management System through the Network.

Hardware

- o Helped assemble Personal Computers from parts
- o Troubleshooting hardware and software problems for Personal Computers

Administrative

- o Data Management Group Leader,supervising 6 persons involved in Data Management, Data validation and Data verification
- o Member of Telephone Systems selection committee
- o Member of GIS(Geographic Information System) selection committee
- o Database Administrator and User Consultant
- o Educated and trained personnel to use software and hardware products
- o Evaluated and recommended software products to management

LINDSAY D. NAKASHIMA

coastal geomorphology
GIS/remote sensing
oil spill contingency
planning/response

EDUCATION

Rutgers University, New Brunswick, NJ: Ph.D., Physical Geography, 1984
Wilfrid Laurier University, Waterloo, Ontario: M.A., Physical Geography, 1977
University of Toronto, Toronto, Ontario: B.S., Physical Geography, 1974

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Assistant Project Scientist, 1990 - present.
Woodward-Clyde Consultants, Senior Staff Scientist, 1989 - 1990.
Louisiana Geological Survey/Louisiana State University, Baton Rouge, Louisiana, Research Associate, 1985 - 1989.
Trent University, Peterborough, Ontario, Geography Department, Assistant Professor 1984 - 1985.
Ryerson Polytechnical Institute, Toronto, Ontario, Lecturer, Applied Geography Department, 1983 - 1984.
Brock University, St. Catharines, Ontario, Lecturer, Geography Department, 1982-1983.
Rutgers University, New Brunswick, NJ, Center for Coastal and Environmental Studies, Graduate Research Assistant, 1976 - 1982.

REPRESENTATIVE EXPERIENCE

Dr. Nakashima is a coastal geomorphologist with more than 15 years of experience and a strong publication record in the field of coastal sediment transport, mapping, and management. He has worked as part of the WCC team evaluating the Exxon Valdez oil spill impacts and directing cleanup efforts in the the Alaskan Peninsula and Prince William Sound. During the last two years, he has conducted aerial videotape and ground surveys as part of Exxon's spring, summer and fall beach assessments. He has also managed fieldwork and mapping of wetlands sedimentation and habitat in Louisiana and Georgia. He has also conducted many site analyses, written several sampling plans, and performed numerous data analyses of hydrodynamic studies and PCB contamination in sediments for sites in Louisiana, Mississippi, and New York. Dr. Nakashima will be responsible for GIS applications at WCC-Baton Rouge and for the design and implementation of reconnaissance field surveys required for development and evaluation of future wetlands erosion mitigation, oil spill contingency planning and response, and coastal restoration projects.

Dr. Nakashima joined WCC from the Louisiana Geological Survey of Louisiana State University. There, as Research Associate, he gained recognition for his management of several statewide field programs and for innovation in the application of microcomputer systems for analysis of nearshore process, sedimentation, and mapping data.

Dr. Nakashima has a close working relationship with the Coastal Engineering Research Center (CERC) at the USCOE Waterways Experiment Station in Vicksburg, Mississippi, and has served on two occasions as an invited principal investigator in the nearshore processes and sediment transport field experiments conducted at the CERC facility in Duck, North Carolina.

REPRESENTATIVE ACTIVITIES

- Principal investigator - project manager of field projects
- Water sampling: estuarine dissolved oxygen, salinity, temperature
- Invited principal investigator: (Sediment transport), U.S. Army Corps of Engineers, Nearshore processes and sediment transport field experiments I.
- Invited principal investigator: (Sediment transport), U.S. Army Corps of Engineers, Nearshore processes and sediment transport field experiments II.
- Field trip leader: NY State Association of Geologists; NJ State Association of Geologists
- Invited participant: NJ Governor's Scientific Advisory Committee on Sea Level Rise
- Statewide field surveys: beach & dune morphology: NJ Geological Survey, LA Geological Survey
- Air photo interpretation, remote sensing, and GIS applications
- Sediment sampling: Dutch corer, vibracoring, bed load, suspended load
- Sediment transport: Eolian traps, E-M current meters, pressure transducers, wave staffs, surf zone traps

RESEARCH CONTRACTORS

Canada, Social Science and Humanities research Council, Toronto, Ontario
Louisiana, Department of National Resources, Baton Rouge, LA
U.S. Department of the Interior, National Park Service, North Atlantic Office, Boston, MA
U.S. Department of the Interior, National Park Service, Southeast Region, Atlanta, GA
U.S. Army Corps of Engineers, Vicksburg, MS

PROFESSIONAL AFFILIATIONS

American Geophysical Union
American Society for Photogrametry
Association of American Geographers
Coastal Education Research Foundation
Society of Economic Petrologists and Mineralogists

PUBLICATIONS AND PRESENTATIONS

Nakashima, L.D., Cofer-Shabica, S.V., Day, Jr., J.W., Reed, D.J., Knaus, R., Boumans, R., Kemp, G.P. and Owens, E.H., 1990, Changes in Marsh - Mudflat Sedimentation on Cumberland Island, Georgia, Coastal Zone '91, ASCE, in press.

Nakashima, L.D. & Mossa, J., 1991, Responses of Natural And Seawall-Backed Beaches To Recent Hurricanes On The Bayou Lafourche Headland, Louisiana, Zeitschrift fur Geomophologie, in press.

Kraus, N.C. & Nakashima, L.D., 1991, Hydrodynamics and sediment transport in a rip current system, Journal of Geophysical Research, in preparation.

Nakashima, L.D., 1989, Shoreline responses to Hurricane Bonnie in Southwestern Louisiana, Journal of Coastal Research, 5:127-136.

Mossa, J. & Nakashima, L.D., 1989, Variations in natural and artificial beach systems on the Bayou Lafourche headland, Louisiana, Coastal Zone '89, American Society of Civil Engineers, pp. 3723 - 3737.

Nakashima, L.D., Hanson, H. & Kraus, N.C., 1989, Shoreline change behind segmented detached breakwaters at Holly Beach, Louisiana: Prototype behavior and model prediction, Coastal Zone '89, American Society of Civil Engineers, pp. 568 - 582.

Nakashima, L.D., 1988, Short-term beach changes along the Louisiana coast, Transactions, Gulf Coast Association of Geological Societies, 38:323-329.

Nakashima, L.D. & Louden, L.M, 1988, Interpretive summary: Water level change, sea level rise, subsidence, and coastal structures in Louisiana, Report to Coastal Engineering Research Center, U.S. Army Corps of Engineers, Vicksburg, MS, Louisiana Geological Survey, Louisiana State University, Baton Rouge, LA.

Nakashima, L.D., Mossa, J., Ramsey, K.E., & Louden, L.M, 1988, Influence of changing water level on coastal structures in Louisiana, Coastal Engineering Research Center, U.S. Army Corps of Engineers, Louisiana Geological Survey, Louisiana State University, Baton Rouge, LA.

Nakashima, L.D., Pope, J., Mossa, J. & Dean, J.L., 1987, Initial response of a segmented breakwater system, Holly Beach, Louisiana, Coastal Sediments '87, ASCE, New Orleans, LA, p. 1399-1414.

Nakashima, L.D., 1987, Documentation of nearshore topographic changes and nearshore circulation through repeated surveys and the use of drogues, respectively, in Louisiana, Louisiana Geological Survey, Technical Report, for Department of Natural Resources, DNR #21940-87-02, Baton Rouge, LA.

Nakashima, L.D., 1987, Shoreline changes in Louisiana, Louisiana Geological Survey, Technical Report, for Department of Natural Resources, DNR #21940-86-23, Baton Rouge, LA.

Kraus, N.C. & Nakashima, L.D., 1986, Field method for determining rapidly the dry weight of wet sand samples, Journal of Sedimentary Petrology, 56:550-551.

Nakashima, L.D., 1986, Assessment of an Act 41 shore protection project, Holly Beach, Louisiana, Louisiana Geological Survey, Technical Report, for Department of Natural Resources, DNR #21940-86-01, Baton Rouge, LA.

Nakashima, L.D., 1986, Wetland habitat changes, Louisiana Geological Survey, Technical Report, for Department of Natural Resources, DNR #21940-85-25, Baton Rouge, LA.

Nakashima, L.D., 1986, Shoreline changes along the Louisiana coast 1985-86, Louisiana Geological Survey, Technical Report, for Department of Natural Resources, DNR #21940-85-25, Baton Rouge, LA.

Penland, S., Suter, J. & Nakashima, L.D., 1986, Hurricane erosion and barrier island protection in Louisiana, Louisiana Conservationist, 38:22-25.

Nakashima, L.D., 1985, Coastal erosion monitoring project, Louisiana Geological Survey, Technical Report, for Department of Natural Resources, DNR #21940-84-01, Baton Rouge, LA.

Nakashima, L.D., McCluskey, J.M., Psuty, N.P. & Gares, P.A., 1983, Management implications for a rapidly eroding beach, Coastal Zone '83, American Society of Civil Engineers, San Diego, CA, p. 682-696.

Nakashima, L.D., 1982, Nearshore dynamics at South Beach, Sandy Hook, New Jersey, Proceedings, Middle States Division, Association of American Geographers, Montclair, NJ.

Nakashima, L.D., McCluskey, J.M. & Psuty, N.P., 1982, Beach changes at South Beach, Sandy Hook Unit, Gateway National Recreational Area, New York and New Jersey, Final Report, National Park Service, Center for Coastal and Environmental Studies, Rutgers University, New Brunswick, NJ.

Nakashima, L.D., 1981, Effects of ocean waves on a sand bag seawall emplaced at Sandy Hook, New Jersey, in: Nordstrom, K.F., Allen, J.R., Sherman, D.J., Nakashima, L.D. & Psuty, N.P., Assessment of management problems and management strategies for the shoreline of Sandy Hook Spit, Gateway National Recreation Area, Vol. II, National Park Service, Center for Coastal and Environmental Studies, Rutgers University, New Brunswick, NJ.

Psuty, N.P., Nakashima, L.D. & Theokritoff, G., 1980, Coastal dynamics and environments on Sandy Hook, Field Trip Guide Book, Annual Meeting, New York State Geological Association, Rutgers University, Newark, NJ.

Nakashima, L.D., 1979, Shoreline orientation, breaker height, and volumetric beach changes at Sandy Hook, New Jersey, Proceedings, Middle States Division, Association of American Geographers, 9:71-76, Syracuse, NY.

Abstracts

Weeks, D. and Nakashima, L.D., 1990, Hydrologic Equilibrium in Wetlands of the Turner River Basin, Sixth Conference Research and Resource Management National Parks, George Wright Society, El Paso, Texas.

Nakashima, L.D. and Mossa, J., 1990, Changes in Beach Morphology Along the Louisiana Barrier Island Coast, Coastal Sediments '91, ASCE.

Nakashima, L.D., 1989, Evaluation of Changes in Beach Morphology Along the Louisiana Barrier Island Coast, Transactions, Gulf Coast Association of Geological Societies.

Nakashima, L.D., 1988, Short-term beach changes on the Louisiana coast, American Association of Petroleum Geologists Bulletin, 72:1119.

Kraus, N.C. & Nakashima, L.D., 1987, Field measurement of a rip current: Fluid and sediment movement, EOS, Transactions, American Geophysical Union, 68:1311-1312.

Nakashima, L.D., 1986, Long-term equilibrium and shoreline mobility of natural and developed barrier island systems, Louisiana, Geological Society of America, Annual Meeting, Orlando, FL, p. 674.

Penland, S., Suter, J. & Nakashima, L.D., 1986, The geological impact of the 1985 hurricanes in the northern Gulf of Mexico, Louisiana Engineering Professional Association, Annual Meeting, New Orleans, LA.

Penland, S., Suter, J., Nakashima, L.D., Reimer, D. & Sallenger, A., 1986, Morphodynamic signature of the 1985 hurricane impacts on the northern Gulf of Mexico, Transactions, Gulf Coast Association of Geological Societies, Annual Meeting, Baton Rouge, LA.

Nakashima, L.D., 1984, Sediment transport modes under varying breaker conditions, Annual Meeting, Association of American Geographers, Abstract, Washington, D.C., p. 63.

Psuty, N.P. & Nakashima, L.D., 1983, Late Holocene sea level transgression in coastal New Jersey, NJ Academy of Science, Abstracts, N.J. Institute of Technology, Newark, N.J.

Nakashima, L.D., 1983, A beach-bar interaction model, International Association of Sedimentologists, Abstract, 11:101, Hamilton, Ontario.

Nakashima, L.D., 1982, Sediment transport rates in barred and non-barred nearshore topographies, Annual Meeting, Association of American Geographers, San Antonio, TX, p. 53.

Nakashima, L.D., 1981, Littoral drift characteristics and beach response rates with respect to changes in shoreline orientation, Annual Meeting, NJ Academy of Science, Abstract, 26:69, Mays Landing, NJ.

Nakashima, L.D., 1979, Application of the allometric growth concept to a recurved barrier spit system, Annual Meeting, NJ Academy of Science, Abstract, 24:91, Lawrenceville, NJ.

KIRAN K. SRINIVASAN

statistical analysis
hazardous waste management
wastewater treatment system design
groundwater modeling and remediation
RI/FS
RCRA facility investigation

EDUCATION

Tulane University, M.S., Environmental Engineering, 1989
Bangalore University-India, B.S., Industrial & Production Engineering, 1984

REGISTRATION

Registered Environmental Professional - Chartered Engineer (India)

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Staff Engineer, 1989 - Present
Tulane University, Research Assistant, 1988-89
TTE Engineering Works Ltd., India, Engineer, 1985-87

REPRESENTATIVE EXPERIENCE

Mr. Srinivasan joined Woodward-Clyde Consultants' Baton Rouge Operating Unit as a Senior Staff Engineer in the Water Quality and Treatment Group. He has extensive experience in the area of wastewater treatment, groundwater management, and hazardous waste management. Examples of his project experience include:

- conceptual design of wastewater treatment systems and preparation of state and NPDES water permits for several companies located in Louisiana, Mississippi, Alabama, and Tennessee.

- auditing a client's existing wastewater treatment system at four sites throughout south Louisiana, which included identification of problems and bottlenecks, conceptual design of new wastewater treatment systems, preparation of state and NPDES water permits, and an environmental assessment of all facilities at the sites.

- designing a biological waste treatment system to treat high-strength organic and oily wastes for a client in Louisiana.

- designing a treatment system to reduce TSS and zinc levels in outfall to achieve NPDES permit compliance for a client in Louisiana.

- troubleshooting a client's wastewater treatment unit on an offshore platform, including remediation measures and system start-up.

- conducting oxygen transfer efficiency test at a 1.3 million gallon capacity aeration tank for a client in Louisiana.

- conducting pumping tests at three sites to determine aquifer characteristics, including one site contaminated with aniline for which tests had to be performed under "modified level-C" conditions; preparing an RI/FS report for the aniline contaminated area for submission to the regulatory agency.

- reviewing an RI/FS report for a Superfund site in Ohio to evaluate the technical approach, models, remediation alternatives, and conclusions adopted by EPA in evaluating the site.

- preparing an RI/FS workplan for a chemical facility in Alabama.

- preparing an RFI workplan for a chemical facility in Louisiana.

- managing groundwater monitoring and reporting programs consisting of about 100 wells for hazardous waste and solid waste facilities for a client in Louisiana.

- computer modeling of groundwater remediation schemes for a client in Louisiana.

- preparing a proposal for SARA-Community Right-To-Know Sections 311 and 312 reporting for a client in Louisiana.

- groundwater assessment/low pH remediation study for a client in Louisiana.

- groundwater modeling project using SUTRA to determine contaminant migration for a client in Louisiana.

While in graduate school at Tulane University, Mr. Srinivasan worked as a Research Assistant in the School of Civil Engineering where he assisted in establishing the new Environmental Engineering laboratory. Mr. Srinivasan has extensive experience in the use of various project management software and application packages. His areas of expertise also include operations research, quality assurance, probability and statistics, toxicology and environmental microbiology.

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers
Air and Waste Management Association
National Registry of Environmental Professionals
Institute of Industrial Engineers
Institute of Engineers (India)

KATHY S. BURNS **QA/QC**
data validation

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Data Management Specialist, 1989 - present.
ETC/Toxicon, Report Production Group Leader, 1987 - 1989.
ETC/Toxicon, Word Processing, Supervisor, 1987.
Toxicon Laboratories, Inc., Word Processing Operator, 1986.
Ronald W. Wall, Attorney at Law, Office Manager and Legal Secretary, 1983 - 1984.

REPRESENTATIVE EXPERIENCE

Ms. Burns joined Woodward-Clyde Consultants as a Data Management Specialist with responsibilities for data review and validation. Her background includes over three years of experience in laboratory quality assurance practice. At Woodward-Clyde, Ms. Burns reviews laboratory generated final reports to clarify and/or correct discrepancies in the reports. She assesses data quality based on data quality objectives, method protocols and established EPA guidelines, ensuring compliance with specified quality assurance/quality control procedures. She consults with regulatory agencies and/or researches reference materials to obtain documentation or information not defined in guidelines used to assess data.

Prior to joining Woodward-Clyde Consultants, Ms. Burns was employed with ETC/Toxicon, a medium-size, full service environmental laboratory. As Report Production Group Leader, Ms. Burns' responsibilities included providing preliminary assessment of all data, assembling extensive EPA data packages, reproduction and distribution of all Contract Laboratory Program (CLP) data packages while maintaining confidentiality, and data chain-of-custody for the current U.S. EPA organic megacontract. She also organized and maintained the EPA contract file, monitoring and responding to all contract required document deliverables which included Contract Compliance Screening, Organic Traffic Reports, Backlog Inventories, Invoice Discrepancy Reports, and Reconciliation.

Data Archival included assuring that all documents for a specified case were accounted for from case initiation through case submission. Accountable documents included logbooks, chain of custody records, sample work sheets, bench sheets and other documents relating to the sample or sample analyses. Data archival was provided for every analytical project in-house for the specified length of the contract or a formal request from the client was received.

KSB
06/90

FERNANDO SIERRA

geology
groundwater monitoring
groundwater hydrology
structural geology

EDUCATION

Louisiana State University, M.S., Geology, 1989
Louisiana State University, B.S., Geology, 1986
Eberhard-Karls-Universitat, Tubingen, West Germany, 1985 - 1986
Universidad de San Carlos de Guatemala, 1982

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Staff Geologist, 1991 - Present.
Universidad de San Carlos de Guatemala, Professor of Geology, 1990.
A.T. Systems School of Computers, Guatemala, Instructor, 1990.
Louisiana State University, Research/Teaching Assistant, 1987 - 1989.

REPRESENTATIVE EXPERIENCE

Mr. Sierra joined Woodward-Clyde Consultants to provide professional and technical support to the Groundwater Quality Assessments Group. His experience includes teaching at the Geology Department of the national university of Guatemala where he was involved in monitoring the flow of groundwater through karstic rocks. His assignments also included teaching hydrogeology, structural geology, subsurface geology, graphic methods, and geologic mapping.

While in Graduate School at Louisiana State University, Mr. Sierra worked in the Department of Geology and Geophysics. His duties included teaching introductory-level geology laboratories and assisting in the maintenance of the Laboratory of Paleomagnetism. His thesis consisted of the study of the late Paleozoic deformation of the Hudson Valley, eastern New York, using the Devonian deformation analysis. Mr. Sierra also has extensive knowledge of subsurface geology, microtectonics, paleomagnetism, plate tectonics, and computer applications to geology.

PUBLICATIONS

McCabe, C., F. Sierra, and A. Schedl, "Late Paleozoic Deformation of the Hudson River Valley, New York," in progress, to be submitted to Tectonophysics.

Sierra, F., "Magnetic Anisotropy and Calcite Twin Analysis of the Onondaga Limestone, Eastern New York: Implications for Deformation History and Mode of Remagnetization," M.S. Thesis, Louisiana State University, Baton Rouge, Louisiana, 1989.

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TIMOTHY J. PFEIFFER

aquaculture
water quality
small pond management
marine biology
surveying

EDUCATION

Louisiana State University, Ph.D. Candidate, Engineering Science, 1990
Auburn University, M.S., Aquaculture, 1989
Oregon State University, B.S., Biology, 1981

PROFESSIONAL HISTORY

Woodward-Clyde Consultants,Staff Scientist, 1990-Present.
CHP International, Inc., Klay, Liberia, West Africa, Technical Trainer, 1989.
Auburn University, Aquaculture Training Program, Training Coordinator, 1989.
Auburn University, Department of Fisheries, Graduate Research Assistant, 1987 - 1988.
Northern Deep Sea Fisheries, Seattle, Washington, Fisheries Representative, 1986.
National Marine Fisheries Service, Seattle Washington, Research Biologist, 1985.
U.S. Peace Corps, Bhairahawa, Nepal, Fisheries Extension Agent, 1982-1984.
National Marine Fisheries Service, Seattle, Washington, Foreign Fisheries Observer, 1981.

REPRESENTATIVE EXPERIENCE

Tim Pfeiffer joined WCC as a Staff Scientist for the Water Quality and Treatment Group. Mr. Pfeiffer has been working on Tennessee Gas Pipeline Company projects in the areas of site characterization and remediation. He is also involved in field sampling work that includes fish collection, sediment sampling and ground water monitoring.

When overseas in West Africa, Mr. Pfeiffer was the Technical Trainer for the Peace Corps' Liberia Fisheries Program. As Technical Trainer, he provided classroom and field instruction in aquaculture principles to prepare Peace Corps trainees as Agricultural Extension Agents.

After completion of his Master's degree at Auburn University, Mr. Pfeiffer assisted in the coordination of the Fisheries Department's Aquaculture Training Program. He aided in the organization and facilitation of the programs' lectures, lecture material, lab and field work for the training of foreign students in basic concepts of aquaculture. Mr. Pfeiffer's research at Auburn included preparing and stocking ponds, water quality monitoring, fish disease control, preparation and evaluation of fish diets and data collection and analysis.

His fisheries work in the Northwest was mostly with the Pollock fisheries in the Bering Sea. Much of the work involved sampling operations aboard Japanese surimi processing vessels to obtain a perspective of the fish catch composition and quantity.

SITE: OLIN CORP. (MCINTOSH PLANT) NPL
(Operable Unit #1)
Break: 4. 4

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